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Hydropower: Projects & Prospects

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Zou Jiahua on Development of Hydropower Resources

906B0015A Beijing SHUILI FADIAN [WATER POWER] in Chinese No 10, 12 Oct 89 pp 3-4

[Article by Editorial Department of SHUILI FADIAN: "State Council Member Comrade Zou Jiahua [6760 1367 5478] Discusses the Question of Developing China's Hydropower Resources"]

[Text] Editor's note: While outlining China's energy resource strategy recently, State Council member Comrade Zou Jiahua spoke several times about major efforts to develop hydropower resources and related questions. The basic spirit of Comrade Zou Jiahua's talks have important guiding significance for developing China's hydropower industry. For this reason, SHUILI FADIAN is publishing portions of these speeches for the benefit of its readers.

In a speech at the National Energy Resource Work Conference in January 1989, Comrade Zou Jiahua said: "When we speak of the energy resources we are referring to coal, petroleum, hydropower, nuclear energy, and other primary energy resources as well as secondary energy resources converted to electric power." In outlining structural problems in the energy resource industry, particularly in the electric power industry, Comrade Zou Jiahua said: "Because we cannot simply rely on coal to meet power generation needs, consideration of thermal power construction should be combined with consideration of the question of hydropower construction. China is very rich in hydropower resources, but only about 8 percent has been developed now, so we should accelerate development." "Some feel that hydropower resource development involves large investments and long schedules, so developing hydropower is not economical. Is this really the case? In a direct comparison of hydropower stations and thermal power plants, hydropower stations certainly do require larger investments, but they are not entirely comparable because building thermal power plants also requires coal construction and transport construction. Otherwise, thermal power plants will lack fuel after they are built and cannot generate power. If we include the cost of coal mines and transport capacity in the calculations, there is not much difference in the cost of the two. Moreover, hydropower is a renewable energy resource whereas excavating a ton of coal means there is 1 less ton. We should acknowledge the superiority of hydropower and focus on hydropower development." "Some have pointed out that hydropower has problems with wet and dry seasons and can only be used for peak regulation. There is a certain basis for this idea, but if we try to develop locations with rather stable flow rates first when choosing hydropower projects or if we use reservoirs for regulation, this problem can be solved." "Hydropower construction should adopt the principle of integrating large, medium, and small scales. We do not oppose building large hydropower stations, and they can be built if they are the subject of sufficient debate and can truly benefit the national economy. However, debating large-scale hydropower projects takes a long time, and they cost more and take longer to build. They should be adapted to national strengths and considered within the range that national strengths permit. Medium and small-scale stations involve smaller investments and somewhat shorter construction schedules, so the capital can be recovered more quickly and the recovered capital can be used to build a second group of medium and small-scale hydropower stations. This sort of rolling arrangement can play a substantial role within a specific time period. I have received many opinions like this which advocate beginning with tributaries and carrying out cascade development, organizing hydropower development companies according to river basins, and enabling hydropower itself to achieve benign cycles. Comrades can consider these opinions." "We cannot compel uniformity for all areas of China. Thermal power and hydropower projects should be arranged according to each area's resource conditions and characteristics." While discussing the question of everyone developing energy resources, Comrade Zou Jiahua said: "Energy resources should be developed by everyone through integration." "We have accumulated much experience in everyone developing electric power and coal over the past few years. We should continue to adhere to this principle in the future, rely on central authorities and local areas for development, and rely on integration between central authorities and local areas, and on local areas and local areas for development. I heard recently that Guangdong wants to integrate with Guizhou and Guangxi to develop hydropower, and I fully support this. This type of method has very good development prospects."

While inspecting the construction site at Qinshan Nuclear Power Station in Zhejiang on 13 February 1989, Comrade Zou Jiahua said: "China has an energy shortage and we should develop all types of electric power. Some say that hydropower costs more to build than thermal power, but if we consider investments in coal mines and railway communications, hydropower and thermal power cost the same to build. We cannot use thermal power to argue against hydropower. Our coal resources and extraction capacity are limited, so we must develop nuclear power. We cannot wait until all our coal is extracted before we begin developing nuclear power, nor can we use other sources of electricity to argue against nuclear power." He also said: "China now gets 75 percent of its energy from coal. There should be a major effort to develop hydropower resources, but in the long term it will not be enough to rely only on coal and hydropower. The current focus can be on coal and hydropower, but the long-term view should make nuclear power an important point." He also said: "No one should be worried. The state now has energy resource and capital shortages. All meetings of central

authorities talk about slanting toward energy resources and communications. Regardless of how we wish to develop energy resources, the future depends on energy. Coal and electric power shortages have made everyone understand clearly that there is an even greater need for slanting."

While listening to views of officials in Sichuan Province on 8 May 1989 regarding development of Sichuan's hydropower, Comrade Zou Jiahua said: "I support Sichuan's major efforts to develop hydropower resources. Sichuan cannot depend on coal. When a province has no coal, it is hard to ship it in from other regions, so there should be major efforts to develop hydropower." While discussing development principles for hydropower and thermal power, he said: "First, combine hydropower and thermal power and adapt to local conditions. Second, in hydropower we should integrate large, medium, and small scales, and focus on medium and small scales at the present time. Third, there should be a combined focus on high and low heads. Fourth, there should be cascade development and comprehensive utilization. Hydropower resources should be fully utilized." When discussing economic issues regarding hydropower, Comrade Zou Jiahua said: "Hydropower requires large investments, but when discussing investments we cannot talk only about power plants themselves. If we consider opening mines and building railroads for thermal power and the compensation and inundation involved with hydropower, there is not much difference between the two. This view is gradually gaining acceptance, but we still neglect consideration of operating costs and environmental protection. Construction schedules should be shortened for hydropower and we cannot simply make inputs without gaining output. There must be concepts of time and interest." While discussing the establishment of river basin hydropower development companies, he said: "I support basin companies and giving the companies three tasks. With a prerequisite of adhering to the above principles, they should first, raise investments, second, take responsibility for construction and management, and third, do their own rolling and cascade development. The state can provide initial support and they can accumulate their own funds." While discussing sources of fund, he said: "There should be many capital channels. Provinces should be the main sources for medium and small-scale projects and there should be many channels within provinces. Prefectures and cities can raise funds, banks can provide loans, and foreign investments can be used." Comrade Zou Jiahua also said: "To assure a 7 percent yearly economic growth rate up to the year 2000, electric power must expand to 240,000 MW. However, coal-fired power can only reach 70,000 MW and nuclear power will be limited, so besides a major effort to develop coal-fired power, we also should work as hard as possible to develop hydropower and try to conserve electricity and reduce energy consumption."

Energy Minister Backs Acceleration of Hydropower Construction

906B0015B Beijing SHUILI FADIAN [WATER POWER] in Chinese No 10, 12 Oct 89 pp 4-6

[Article by Huang Yicheng [7806 3015 6134]: "Use the Spirit of Reform To Accelerate Development of China's Hydropower Resources—Written for the 'Special Issue Commemorating the 40th Anniversary of the Founding of the Nation' Published by SHUILI FADIAN"]

[Text] Hydropower and coal are China's two biggest energy resource advantages. China has enormous hydropower resources, among the largest in the world. Surveys show that China has theoretical hydropower resource reserves of 676,000 MW which could generate 5.92 trillion kWh of electricity yearly. Of this amount, 378,000 MW is developable, for yearly power output of 1.92 trillion kWh. Thus, we should take full advantage of China's hydropower resources and make accelerating hydropower construction a basic strategy for China's energy resource industry.

Since the founding of new China, the CPC and government have been extremely concerned with the cause of hydropower construction and there have been substantial developments in hydropower construction and utilization. At the time of the nation's founding in 1949, China had just 163 MW in hydropower installed generating capacity which generated 710 million kWh of power annually. After 40 years of construction up to the end of 1988, China's hydropower installed generating capacity expanded to 32,700 MW, equal to 28.3 percent of China's total electric power installed generating capacity of 115,500 MW and sixth place in the world. Yearly power output from hydropower was 109.2 billion kWh, equal to 20 percent of annual power output in China and fifth place in the world. Our preliminary plans call for adding 50,000 MW in hydropower installed generating capacity by the year 2000 and attaining yearly hydropower output of 240 billion kWh. After this goal is attained, the degree of hydropower development in China will only increase from the 8.4 percent now to 20 percent, so the degree of hydropower resource utilization in China will still be very low. Nevertheless, we face many problems in attaining this goal and should soberly acknowledge this point.

In the area of electric power development in China, there has been a fight between hydropower and thermal power for many years. Hydropower is a renewable conventional energy resource with low power generation costs and no pollution. Everyone acknowledges this. Developing hydropower permits simultaneous development of primary energy resources and conversion of secondary energy resources, which is the same as building thermal power plants and coal mines. When a hydropower station is finished, cheap electric power can be gotten without fuel, and scientific, rational dispatching can save large amounts of coal and oil every year. Moreover, hydropower generators are easy to start up and shut down, and they have good regulation capabilities, so they

are suitable for peak regulation and accident reserves in power grids and are an excellent power source for grids.

If hydropower has so many advantages, why is it so hard to develop? There are external obstructions and internal problems. For many years, the most acute problem facing hydropower development has been the three hats we wear. They are hydropower's long construction schedules, large investments, and problems in dealing with inundation and resettlement. Of course, there are many unfair and less than comprehensive sides to this view of hydropower construction, but it does provide a concise reflection of hydropower construction problems which urgently demand reform.

Those who speak of hydropower's long construction schedules, large investments, and difficulties in dealing with inundation and resettlement mainly feel that building a thermal power plant usually takes 3 or 4 years, and the fastest can be built in 2 years and generate power. Hydropower stations, however, usually take 7 to 10 years, so hydropower takes longer to build than thermal power. Developing thermal power usually costs about 1,000 yuan per kW and the yearly operating time is about 6,000 hours, whereas the operating time for the hydropower is usually about 3,000 hours, so the investment in hydropower is greater than that for thermal power. Hydropower construction usually requires building reservoirs and raising water levels, which demands flooding of some farmland and poses resettlement problems.

We feel that hydropower construction schedules may be longer and the initial investment greater than thermal power, but if thermal power is to function after it is completed there must be corresponding development of coal mines and construction of communications. If we consider these factors, hydropower construction schedules are not necessarily too long and the unit investment is not high. Building hydropower stations also provides substantial added benefits for flood prevention, waterborne transport, irrigation, and other areas. Usually, people only see one side of hydropower stations, farmland inundation. Actually, building a reservoir assures irrigation and flood prevention for downstream areas and creates much good land. Miyun Reservoir flooded less than 300,000 mu of land and created nearly 700,000 mu. A large area of good land was also created downstream from Guanting Reservoir.

Our multifaceted propaganda about the good side of hydropower permits people to be as objective as possible and treat hydropower development fairly. From another aspect, however, comrades involved in hydropower construction should search more for factors inside us, use the spirit of reform to deal with our work, formulate truly feasible measures, try to remove these three hats from our heads, and accelerate hydropower development in China.

Accelerating hydropower development first of all requires a flexible macro plan. China has many river, lake, and pond basins. Many treatises can be written about how to use geographic and resource advantages, carry out cascade development of river basins, and in particular give preference to developing "motherlode" river segments with abundant hydropower resources, superior construction conditions, and good economic results. In hydropower development deployments, we should focus on developing large-scale hydropower stations on the upper reaches of the Huang He, the trunk and tributaries of the Chang Jiang, the Hongshui He basin, the Lancang Jiang, and other areas where 25,000 MW in generators have been completed and placed into operation over the past 10 years. We should actively build medium-scale hydropower stations in regions which lack energy resources but have good hydropower resource conditions and superior technical and economic indices. The investments should come mainly from local areas, departments, and enterprises with the state providing part of the investments in an effort to build 10,000 MW in generators within 10 years. In grids with weak peak regulation capabilities and large peak-to-valley system differentials, we should build several pumped storage power stations.

Accelerating hydropower development requires reform of the existing management system. The State Council has already approved a reform program for the electric power system. Reforms in hydropower development should center on implementing mechanisms to enable self-development in hydropower. For a long time, hydropower has developed under conditions of investment shortages and distorted electricity prices. Hydropower originally was a moneymaking enterprise but the unified accounting system we use in our financial system has formed a "big common pot" in power grids which conceals enterprise profits or losses, so hydropower's advantages have not been apparent. In the future, we should organize hydropower development companies according to river basins or regions with the state providing support and assistance for startup capital and rolling development for gradual cascade development of basins and sequential construction to accelerate the pace of hydropower construction and reduce hydropower project construction costs. Implementation of independent financial accounting in newly built hydropower stations is related to electricity prices in grids. Economic contracts should be signed so grids can recover administrative costs from electricity sales. In this way, hydropower profits are basically returned to hydropower. Power plants should practice independent decisionmaking and be responsible for their own profits and losses. This would give hydropower a self-development capability. The design system also should be reformed. Designs should be used as a tap to integrate with construction companies and establish independent companies to take responsibility for "turnkey" projects to implement fully integrated construction services all the way from design and construction to transfer and utilization.

Accelerating hydropower development also requires shorter construction schedules as breakthrough points to use existing capital well, adopt advanced design and advanced technologies, and import competitive mechanisms. There are examples of early completion and startup in our hydropower construction in the past. It took just 3 years at Xin'an Jiang Hydropower Station from the start of construction in 1957 to power generation in 1960. There have been substantial achievements in reducing construction schedules in thermal power in recent years. It took just 26 months from the start of construction to startup and power generation for the 300 MW generator at Zouxian Power Plant. There are good prospects in hydropower construction. The Geheyan project blocked the flow 1 year ahead of schedule and it may generate power one-half year ahead of schedule. Practice has shown many ways to reduce hydropower construction schedules. One major route is design reform and design progress. Design is the tap of a project and savings in design are the greatest type of conservation. Scientific debate has shown that reducing excavation by a few meters for the foundation at Ertan could save substantial amounts of concrete. In contrast, inadequate preparatory work for building Longyang Gorge Hydropower Station has revealed design problems during construction which have raised costs and lengthened the construction timetable. Importing competitive mechanisms, implementing the submission of tenders and solicitation of bids, and breaking down departmental and regional protectionism also can promote competition between design departments and between design and construction department, reduce project costs, and shorten construction schedules.

Accelerating hydropower development also requires complete fostering of initiative in all areas. The state now invests over 2 billion yuan annually in hydropower, but we cannot simply rely on these funds. We also should try to get more than 2 billion yuan by formulating policies to raise capital and attract foreign investments. Make use of the guiding role of state investments in energy resources in the area of hydropower construction, take advantage of the Huaneng Group in the area of key energy resource construction projects, and widely absorb local capital and enterprise financial strengths. A 0.02 yuan per kWh "electric power construction fund" from hydropower should be used for hydropower construction to raise 6 billion yuan in investments each year in the short term. In the area of hydropower construction, attention should be given to fostering local initiative. Cooperation between the state and local areas in building hydropower stations with a partial division of power rights and power use rights and return of benefits to localities will foster local initiative. This will enable localities to solve many problems themselves and substantially accelerate project progress.

Accelerating hydropower development first of all requires a spirit of reform and adopting development methods to solve resettlement problems. Past examples show that compensation methods to solve resettlement problems leave quite a few residual problems. Xin'an Jiang Hydropower Station has been completed for 30 years now but resettlement problems remain unresolved. Using a development method and compensation funds to help those resettled to develop sideline production and processing industry enterprises will create employment opportunities and turn peasants into workers after a few years. They will grasp certain production capabilities, their lives will be stabilized, and resettlement problems will be solved. By doing things this way, the cost of solving resettlement problems may be somewhat less than the compensation funds used in the past.

In summary, China's extremely abundant hydropower resources can be developed for more than 100 years at the present rate of development, so hydropower involves heavy and long tasks. If we do not reform certain policies and methods now in effect, and if we do not try in every way to eliminate the three hats that hydropower development has placed on our heads, accelerating hydropower development will be impossible and we may even find ourselves in dire straits. The motherland's precious hydropower resources may slip from our grasp. At that time, we will have shamed our motherland and it will be impossible for us to turn it over to our descendants. In contrast, if we boldly reform and work hard to innovate, we can accelerate hydropower development in China and permit our rich hydropower resources to produce benefits for economic construction in China at an early date, thereby accelerating achievement of China's major four modernizations drive.

Water Resources Minister on Role of Hydropower

906B0015C Beijing SHUILI FADIAN [WATER POWER] in Chinese No 10, 12 Oct 89 pp 7-9, 16

[Article by Minister of Water Resources Yang Zhenhuai [2799 2182 2037]: "Comprehensive Development and Control of China's Rivers and Water Resources and Electric Power"]

[Text]

I

China has a huge population and a vast territory, many rivers, and abundant water resources. We have over 50,000 rivers with basins larger than 100 square kilometers in area. Preventing destruction by water and building water conservancy have extremely important positions in China and they have been major aspects of managing national affairs throughout our history. The long-term national average precipitation in China is 650 mm, which provides rich water resources for our rivers. However, the effects of terrain and climate cause precipitation in China to have uneven temporal and spatial distributions. There is more rain in the southeast and less in the northwest, and most precipitation is concentrated in the 3 months of July, August, and September. There is a concentration of thunderstorms in the summer which rivers cannot drain off, often resulting in

flooding. When floodwaters exceed existing flood prevention capabilities, nearly one-tenth of our territory, one-half of our population, and two-thirds of our gross value of industrial and agricultural output are endangered to varying degrees.

China has a total of 2.8 trillion cubic meters of water resources but the amount available per capita is only 2,500 cubic meters, just one-fourth the average per capita amount available worldwide. This means that China has a water shortage. In this situation, rational development and utilization of the water resources in our rivers has extremely great importance and roles in development of our national economy and society. China's rivers have extremely abundant hydropower resources, with developable hydropower resources of 378,000 MW, first place in the world. In the current situation of a serious national power shortage and inadequate coal supplies, a major effort to develop hydropower to alleviate the power shortage is especially important. China also has extremely abundant water-borne transport resources. We have over 1,500 rivers covering basins larger than 1,000 square kilometers. Most of these basins are not subject to freezing during the winter and have abundant water, which are excellent conditions for developing water-borne transport. In addition, China's many rivers, lakes, ponds, reservoirs, and other large bodies of water provide vast prospects for developing aquaculture, tourism, and other industries.

II

In the 40 years since the nation was founded, the CPC and government have led the Chinese people in developing large-scale water resources and hydropower construction and in implementing comprehensive development and control of our rivers. China has repaired and built over 200,000 kilometers of river dikes and constructed over 82,900 large, medium, and small-scale reservoirs with a total reservoir capacity of over 400 billion cubic meters. We also have built 108 large and medium-scale hydropower stations with an installed generating capacity of more than 20,000 MW on over 30 rivers. Statistics for the end of 1988 showed a large, medium, and small-scale hydropower total installed generating capacity of 32,700 MW and yearly power output of 109.2 billion kWh, equal to 28.3 percent of the total capacity of China's power generation equipment and 20 percent of our total power output. Reservoirs at large and medium-scale hydropower stations have a total reservoir capacity of over 170 billion cubic meters, equal to 42 percent of China's total reservoir capacity. More than 80 of our 108 large and medium-scale hydropower stations have reservoirs which do double duty for flood prevention and irrigation tasks, equal to more than 70 percent. This includes more than 80 billion cubic meters in reservoir capacity which benefit power generation and irrigation and more than 40 billion cubic meters in flood prevention reservoir capacity, equal to half of the beneficial reservoir capacity. Primary river flood prevention systems include flood prevention projects and water conservancy and hydropower projects protecting more than one-half of China's population and over two-thirds of our gross value of agricultural and industrial output. For several decades, under the leadership and guidance of flood prevention directorates organized by relevant departments in all areas, major victories in struggles against numerous floods substantially reduced floodwater destruction and assured social safety and smooth progress in economic construction. Many hydropower stations with specific regulation reservoirs also provide comprehensive utilization benefits from flood prevention, icing prevention, irrigation, urban and industrial water supplies, aquaculture and breeding, water-borne transport, and so on. Completion of these projects played an enormous role in developing China's industry and agriculture and in raising the people's living standards. An example is Liujia Gorge Hydropower Station on the upper reaches of the Huang He which has a total reservoir capacity of 6.1 billion cubic meters. It provides abundant and cheap electric power for northwest China and plays a role in floodwater regulation in the upper reaches of the Huang He. It has basically eliminated the danger of flooding in Lanzhou City and the danger of icing on the section of the Huang He in Ningxia and Inner Mongolia. Moreover, it can provide Ningxia and Inner Mongolia with an additional 800 million to 1 billion cubic meters of irrigation water in May and June each year. This has enabled irrigation of more than 11 million mu of cultivated land in the Hetao region and it has promoted development of electrically powered irrigation water lifting projects at Jingtai in Gansu, Guhai in Ningxia, and other locations. It has resulted in a net increase of 1.5 billion kilograms in yearly grain output in Gansu, Ningxia, and Inner Mongolia. Another example is Danjiangkou Key Hydropower Project which mainly serves flood prevention and irrigation but also generates power. Since the reservoir was built and stored water, 55 floods in excess of 10,000 cubic meters per second have occurred. After passing through the reservoir and being regulated, the danger has been reduced for 23 downstream counties, a population of 12.8 million, and more than 18.6 million mu of cultivated land. In the area of irrigation, gravity flow water from the Dan Jiang diversion irrigation region has been diverted to irrigate over 3.6 million mu of farmland in Hubei and Henan Provinces. In the area of power generation, the power station has generated a total of 73.342 billion kWh from the time it began generating power in 1968 to the end of 1988. It is now the hydropower station with the best regulation capabilities in the Central China Grid and it plays important roles in assuring grid safety and stable operation, with benefits that are extremely apparent. Other examples are Baishan and Fengman Hydropower Stations built on the No 2 Songhua Jiang. Both are key large-scale power stations in the northeast China electric power system and they are responsible for generating power and for system peak regulation and frequency regulation as well as breakdown reserves. They play an especially important role in assuring safe and stable grid operation. In the area of flood prevention, these two power stations, particularly Fengman Power Station, are

major flood prevention projects on the Songhua Jiang water system. They are related to safety of the entire Songhua Jiang water system and protect the safety of cities and towns in the lower reaches of the Songhua Jiang, particularly Harbin. Since the reservoir began storing water and operating, there have been two floods which occur at a frequency of once every 100 years (in 1953 and 1957). The biggest flood was in August 1953 when the peak floodwater flow entering the reservoir was 17,200 cubic meters per second. The maximum amount of drainage after regulation was 7,550 cubic meters per second, so the reduction in peak flooding was 9,650 cubic meters per second. This reduced flood damage downstream and guaranteed the safety of Harbin City. Fengman Reservoir is also responsible for providing water supplies at the rate of 350 cubic meters per second for downstream farmland irrigation and 100 cubic meters per second for industrial and household water supplies to Jilin City. Construction of many hydropower stations and reservoirs has increased upstream water depths. This has improved water-borne transport in the reservoir region and downstream by regulating floods and dry season flows. Completion of Wujiangdu and Danjiangkou Hydropower Stations, for example, improved water-borne transport conditions on the lower reaches of the Wu Jiang and Han Jiang, respectively, and promoted development of water-borne transport.

III

In the 40 years since the nation was founded, we have built over 60,000 medium and small-scale hydropower stations on medium-sized and small rivers in China's vast rural areas. This is especially true since the 3d Plenum of the 11th CPC Central Committee, when the state confirmed the principle of everyone developing power and motivated local initiative to develop power. This led to substantial development of rural medium and small-scale hydropower and now 1,531 of China's 2,200-plus counties have developed small-scale hydropower. The total installed generating capacity of local medium and small-scale hydropower is 12,312.7 MW. Provinces with over 1,000 MW include Guangdong (1,741 MW), Sichuan (1,515.2 MW), Hunan (1,369.7 MW), Fujian (1,136 MW), and others. Growth in the medium and small-scale hydropower installed generating capacity has gradually formed and developed local grids in rural areas which are dominated by medium and small-scale hydropower, and they have formed their own power supply regions. The availability of electricity has brought development to agriculture and to township and town industries. Local initiative to develop power is especially high, and they are building power stations and power grids. County-level grids and regional grids have now developed. Multi-county regional grids have developed in Fuling, Wanxian, and Daxian Prefectures in Sichuan Province, Huaihua and Shaoyang Prefectures in Hunan Province, Qujing, Chuxiong, and Dali Prefectures in Yunnan Province, and Wuzhou Prefecture in Guangxi Autonomous Region. This is one development trend. These grids are led and managed by water conservancy and hydropower departments (bureaus) in the relevant provinces and autonomous regions. According to county statistics, there are 717 local grids managed by water conservancy departments (mainly medium and small-scale hydropower), equal to 32 percent of China's 2,200-plus counties. Nationally, there are now two marketing patterns for state electric power. They are direct supply of electric power by the state and wholesale sales of state electric power to localities (wholesale purchases and wholesale sales). Besides state electric power, a substantial portion of the power also comes from power stations and grids run by localities themselves and local electric power which is managed, generated, and sold by localities themselves. Local power stations are also connected directly to state grids in an arrangement in which the state grid transfers it for sale. Regions supplied with power by local medium and small-scale hydropower cover about one-third of the administrative areas of China and a population of about 300 million. Most are located in old revolutionary base areas and in minority, frontier, and poor regions. Often, these are also regions not yet reached by large state grids or where very little power is provided even when state grids have been extended to them. It is precisely the implementation of the principle of everyone developing power and relying on local strengths to develop local power stations and local grids that have compensated for inadequacies in state electric power. This is a force which cannot be ignored. Experience in many regions has confirmed that building power stations also requires grid construction and their own power supply regions. This is the lifeline of locally developed power. Just as Premier Li Peng has said, "small-scale hydropower must have its own supply regions and its own local grids. This is the nucleus of developing small-scale hydropower." Negotiated dispatching should be implemented between grids dominated by local medium and small-scale hydropower and large state grids. Because small-scale hydropower grids have poor regulation capabilities and a lower power supply guarantee rate, large grids also should provide the necessary support. Actual conditions show that rural hydropower development plays an important role in rural economic growth. Statistics on conditions during 5 years of experiments in 100 trial electrification counties where small-scale hydropower is predominant show that yearly per capita electricity use was 184.5 kWh in 1988, a 1.28-fold increase over the 81 kWh figure before the experiments. The gross value of industrial and agricultural output was 24.12 billion yuan, up to 95.1 percent from before the experiments. Township and town enterprises grew 4.48-fold and over 3 million peasants obtained employment. Grain output rose 18 percent. Net per capita income rose from 198 prior to the experiments to 501 yuan, a 1.5-fold increase. This has invigorated the rural economy.

IV

Development of hydropower is one goal of comprehensive development and control of China's rivers as well as an important part of water conservancy activities, so

accelerating hydropower construction is also an important duty for water conservancy departments. The "three fixed" program of the Ministry of Water Resources approved by the State Council stipulates that "water conservancy departments are responsible for developing hydropower stations which mainly serve flood prevention, irrigation, and water supplies." "Water conservancy departments are responsible for managing rural hydropower stations and their power supply grids. The state will allocate 100 million yuan yearly from electric power capital construction investments as a capital subsidy to the Ministry of Water Resources for small-scale hydropower." "The Ministry of Water Resources Rural Hydropower Department should join with the Ministry of Energy Resources Rural Electrification Department to build 100 trial rural electrification counties." Based on the range of duties in these stipulations, in the future the Ministry of Water Resources should combine a focus on flood prevention and eliminating danger and on building water conservancy with working on large and medium-scale hydropower construction mainly for flood prevention, irrigation, water supplies, and other comprehensive utilization, and it should continue working on building grids for medium and small-scale rural hydropower and on grids in other areas. The main goals and tasks in plans for water conservancy development in China to the year 2000 are:

1. Consolidate and perfect all types of existing flood prevention facilities and increase the flood prevention capacity on major rivers. Control seven major rivers, the Chang Jiang, Huang He, Songhua Jiang, Liao He, Hai He, Huai He, and Zhu Jiang. Strive for planned operation of large reservoirs and flood control and flood diversion and storage regions on primary rivers for major floods that will occur during this century to ensure the safety of primary river segments and large and medium-sized cities, and to reduce as much as possible the scope of flood damage to guarantee social safety and promote development of national economic construction.

2. Actively promote river control and comprehensive development and utilization of water resources. Integrate with the need for flood prevention on rivers and with hydropower development and other forms of comprehensive water resource utilization. Build key water conservancy projects to control large rivers in a planned manner and solve the water resource shortage in northeast China, the shortage of water resources for water supplies to coastal towns and industries, and problems with human and animal drinking water in rural and pastoral regions in a planned manner. Gradually divert the Huang He into the Dian He and Shanxi and the eastern line for diverting water from south China to north China, actively develop comprehensive utilization hydropower stations, and create the conditions now for building several medium-scale hydropower stations.

3. China's rural areas with a population of 800 million have extremely severe electric power shortages. Average per capita electricity use is just 110 kWh and there are 29 counties and a population of about 250 million in China which still lack electricity. Thus, we must motivate initiative in all areas for a major effort to develop rural hydropower resources and strive to build medium and small-scale hydropower stations in rural areas to transform the rural power shortage situation. Developing medium and small-scale hydropower concerns the two strategic points of rural energy resources and agriculture, and it is a strategic measure which adheres to the overall principle of national economic development in which agriculture is the foundation and industry is the leading factor. Water conservancy departments should seize favorable opportunities and actively create the conditions for building several medium and small-scale hydropower stations. Especially important is the need to build hydropower stations with regulation and storage capabilities or cascade "tap" hydropower stations in local grids where hydropower is dominant. Between now and the year 2000, we should increase the rural hydropower installed generating capacity by 10,000 MW to increase the power supply capacity and power supply guarantee rate in local grids. This is an extremely urgent task for water conservancy departments at all levels.

To achieve the goals of struggle for the year 2000, we must work much harder at comprehensive development and control of rivers, actively develop hydropower, and implement the principle of combining large, medium, and small-scale projects and integrating flood prevention, drainage, irrigation, power generation, water supplies, water-borne transport, aquaculture, and other forms of comprehensive utilization of water resources with river control. Stipulations in the "Water Law" call for water conservancy departments at all levels to serve as water administrative management departments for governments at all levels and to work together with energy resource, communications, aquaculture, and the relevant water-using departments in local areas to actively advocate development of river basins across regional and departmental lines. To achieve good comprehensive prevention of water dangers in rivers and plans for comprehensive development and utilization of water conservancy resources, we should adhere to the principle of unified consideration for all parties, comprehensive administration and comprehensive utilization, concern for results, and taking advantage of the multiple functions of water resources. River control and development are basic facilities for social benefit. Besides increased state investments, we also should motivate initiative in local areas and all benefiting departments for integrated control and development. Besides implementing the principle of everyone building power in hydropower development, we also should take the paths of self-accumulation and self-development. Rural small-scale hydropower development should be treated as power outside of plans which is subject to market regulation. We also should set electricity prices for compensation and repayment of loans and add the increased accumulation to some small-scale farmland water conservancy subsidies and water conservancy capital construction funds, and to prefecture and county

power development funds and other funds as a hydropower development fund.

While discussing small-scale hydropower when listening to reports on the flooding situation on 6 July 1989, Premier Li Peng pointed out that "we cannot allow contraction in small-scale hydropower, since as soon as we contract we will lose everyone's enthusiasm. There is a delivery and receiving relationship between small-scale hydropower and large grids. Power generation from small-scale hydropower is uneven and I thought about this from the beginning. Surveys show that there are no problems. We can use more power in the summer and less in the winter. We can use more when we have it and none when we don't have it. When there is a power shortage in cities, the switches can be thrown and power restricted." He also said: "Small-scale hydropower should have its own power supply regions and original state policies for hydropower will not change." All areas should accelerate rural hydropower and local grid construction in accordance with Premier Li Peng's instructions.

Our experiences in water conservancy and hydropower construction and in operation and management over the past 40 years have shown us that hydropower cannot be separated from comprehensive development and utilization of rivers. It is a part of comprehensive development and utilization of rivers. All relevant departments and regions should work together to undertake all aspects of work in a planned and step-by-step manner in accordance with comprehensive river basin development and utilization plans. Comprehensive river development and control should be combined with efforts to push forward with the cause of hydropower construction in China.

Supporting Hydropower Development To Optimize National Energy Structure

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[Article by Vice Minister Lu Youmei [7120 0147 2812], Ministry of Energy Resources: "Optimize the Energy Resource Structure, Work Hard To Develop Hydropower"]

[Text] China's energy resource industry has made enormous achievements since the nation was founded. This is obvious to all. However, the energy resource industry has lagged behind development of the national economy for quite some time and there is a loss of proportion between energy resources, particularly the electric power industry, and industrial and agricultural development. This situation has severely restricted development of the national economy. For this reason, the state is now adopting a series of slanted policies to gradually readjust this irrational proportional relationship to meet the needs of national economic development. We should note that because of historical factors and system problems, there is also a loss of proportion in development of all areas of China's energy resource industry itself, particularly in the electric power industry. For this reason, readjusting and optimizing the internal structure of the energy resource industry and especially the electric power industry are very important for solving our energy problems, particularly the lack of balance between electricity supply and demand. In the "Special Issue To Commemorate the 40th Anniversary of the Founding of the Nation" organized and published by SHUILI FADIAN, I want to talk about major efforts to develop hydropower in the process of readjusting and optimizing the energy resource structure.

I. The Requirement of Balancing Electric Power in China by the Year 2000 Makes Major Efforts To Develop Hydropower Essential

At a minimum, China's total installed electric power generating capacity must reach 240,000 MW by the year 2000 to meet the need for a 7 to 8 percent growth rate in our national economy. China's present power generation capacity is 110,000 MW, so there must be a net addition of 130,000 MW by 2000. Statistics show that China produced 980 million tons of coal in 1988. Attaining the planned goal of 1.4 billion tons in 2000 would require a net increase of just 420 million tons. China had 75,000 MW in thermal power installed generating capacity in 1988 which burned 220 million tons of coal, about 23 percent of total coal output. Using 25 percent of the 420 million ton net increase in coal output by the year 2000, equal to about 110 million tons, would enable us to add 50,000 MW in thermal power installed generating capacity. If we consider technical progress and adoption of measures to reduce coal consumption, increase the proportion of coal used to generate power, and other things, the maximum increase will be just 70,000 MW. Thus, we must rely on developing hydropower and nuclear power for the other 60,000 MW. The scale for nuclear power now under construction is 2,100 MW and with some effort it may reach 6,000 MW by 2000. Thus, we must depend on hydropower to provide the other 54,000 MW. This means that we must place 5,000 MW of hydropower installed generating capacity into operation each year over the next 11 years.

II. Major Efforts To Develop Hydropower Could Help Increase Economic Benefits in the Energy Resource Industry Itself

For various reasons, hydropower as a proportion of the overall electric power system has declined each year for a long time due to systemic problems and various other factors. There has also been a loss of balance between thermal power development and the development of coal and ways to transport it over the past several years. The result has been coal shortages, transport capacity shortages, and generator shutdowns at thermal power plants. This makes accurate analysis of economic benefits essential for rational readjustment of the electric power structure.

Analysis of the data shows that, based on 1988 price levels, building a typical thermal power plant requires a unit investment of 3,072 yuan per kW. This includes 1,500 yuan invested in the thermal power plant, 739

yuan in coal mine construction, and 833 yuan in transport facilities. Consideration also must be given to the cost of power transmission and transformation for thermal power plants. In contrast, the unit investment to build a typical hydropower station is 2,244 yuan per kWh. This includes 1,600 yuan invested in hydropower station construction and 644 yuan for power transmission and transformation. Analysis of the unit investment for power shows that if we assume a yearly utilization time of 6,000 hours for a thermal power plant, the unit cost of power for building a typical thermal power plant is 0.51 yuan per kWh. This includes 0.25 yuan invested in the thermal power plant, 0.12 yuan in coal mine construction, and 0.14 yuan in transport facilities. Similarly, the investment in transmission and transformation is not considered. To build a hydropower station, however, assuming a yearly utilization time of 4,300 hours, the unit investment for power would be 0.52 yuan per kWh. This includes 0.37 yuan for hydropower station construction and 0.15 yuan for power transmission and transformation.

These conditions show that the power cost indicators are about the same for hydropower and thermal power and that the unit investment per kW for thermal power is about 1.5 times that of hydropower. In the area of construction schedules, it takes about the same amount of time to build a hydropower station as it does to build a coal mine of equivalent scale. This means that, in terms of investment results, building hydropower stations is better than building thermal power plants. If we look at operating costs after operation begins and useful lives, hydropower's superiority to thermal power is even more apparent. This shows that, for the energy resource system as a whole, major efforts to develop hydropower will help increase economic benefits in the entire energy resource industry.

III. Major Efforts To Develop Hydropower Will Aid Energy Resource Conservation and Rational Utilization of Coal Resources

Hydropower is a renewable energy resource, so it is not reduced by using it and cannot be preserved if it is not used. Coal, on the other hand, is a limited resource. It is reduced by use, but it can be saved as a reserve if not used. Although China is rich in coal resources, our large population means that the amount available per capita is not that great. Coal can be used to generate electricity, but it is also an important industrial raw material and there are no substitutes for it in many areas of industry. A major effort to develop hydropower will certainly save substantial coal resources and extend the number of years that our coal resources can be extracted. This has long-term significance for conserving energy resources and developing other industries which use coal as a raw material.

IV. Hydropower Should Comprise a Suitable Proportion in Grids and the Power Source Structure

Hydropower stations are flexible to operate. Generators can be started up and shut down extremely quickly. Thermal power and nuclear power cannot compare. As an economy grows, grids expand, and peak-to-valley load differentials increase, grids as a whole must have more hydropower to assume the burden of system peak regulation, frequency regulations, and accident reserve tasks to increase overall system operating efficiency and reliability.

In the long-term view, grid integration relationships among China's large electric power systems are now developing and grids will continue to grow in size. Formation of a national integrated grid electric power system is an inevitable trend. This electric power system crosses three time zones from east to west and seven climatic zones from south to north. There are obvious differences in temporal, climatic, and load interrelationships in different regions. In this type of situation, hydropower can play an even bigger role in regulation because it can play a balancing role in grids as a whole, particularly in mutual regulation and compensation for hydropower stations in different hydrological conditions, so it can enable overall grids to obtain greater economic benefits. Based on China's characteristics, it would be best if hydropower as a proportion of the electric power system is no less than 30 percent. Using this proportion as a guide, our electric power system should place 5,000 MW of hydropower installed generating capacity into operation each year over the 11-year period from now to 2000.

V. A Major Effort To Develop Hydropower Is in the Long-Term Interests of Mankind

China has a serious water shortage. Our national average amount of water available per capita is just one-fourth that in the United States and one-fifth that in the Soviet Union. Water resources have now become a weak link in development of our national economy. Moreover, geographic and climatic factors give these very limited water resources an extremely irrational temporal and spatial distribution which results in simultaneous drought, flooding, and waterlogging year after year. Major efforts to develop hydropower would inevitably promote control of rivers and change the irrational temporal and spatial distribution of our water resources. It would bring enormous benefits in flood prevention, irrigation, water-borne transport, water supplies, aquaculture and breeding, tourism, and other activities.

Developing hydropower means building dams, making reservoirs, resettling people, and other problems, and it can change the original equilibrium in the natural world and create some negative factors locally. In an overall macro view, however, the result is readjustment of the temporal and spatial distribution of water flows, expansion of the surface water area, and improvement of the natural environment. Unlike a thermal power plant,

using hydropower to generate electricity does not produce large amounts of sulfur dioxide and other toxic gases, nor does it damage the environment. Thus, in this sense, hydropower development helps to improve the ecological environment and the new ecological equilibrium established by building hydropower has positive effects on human existence.

VI. Actively Promote Major Development of Water and Power Construction Activities

In summary, the significance of a major effort to develop hydropower is not limited to readjustment and optimization of the energy resource structure. It is also very important for rational utilization of energy resources, socioeconomic development, and the long-term interests of mankind.

There have been substantial developments in China's hydropower industry in the 40 years since the nation was founded. The hydropower installed generating capacity has increased from 163 MW in 1949 to the present 33,000 MW. However, if we look at the development needs of China's national economy and the current hydropower resource development situation, there are significant differences. The hydropower construction tasks we face are extremely difficult and numerous. We must spare no effort and rouse ourselves to catch up. We believe that after 10 years of hard work on the road to intensive reform, as we approach the 50th anniversary of the nation's founding, besides completing several hydropower construction projects already under way, we also will begin building several world-class hydropower projects like the Three Gorges on the Chang Jiang, Laxiwa on the Huang He, Xiaowan on the Lancang Jiang, Longtan on the Hongshui He, Jinping on the Yalong Jiang, and other large hydropower stations. Our hydropower industry will certainly develop substantially and we will make splendid achievements.

Nation's 20 Major Hydropower Projects Reviewed

906B0015E Beijing SHUILI FADIAN [WATER POWER] in Chinese No 10, 12 Oct 89 pp 62-67

[Article by Zhu Chengzhang [2612 2052 4545] of the Ministry of Energy Resources Comprehensive Planning Office: "Implementing Plans To Build 20 Large Hydropower Stations in China"]

[Text] **I. Introduction**

After the 3d Plenum of the 11th CPC Central Committee, in order to implement the request by the CPC Central Committee and State Council for focusing closely on power and accelerating the pace of construction in the electric power industry, the former Ministry of Electric Power Industry formulated an implementation program adhering to the principle of "readjustment, reform, rectification, and improvement." The program "calls for hydropower to complete a national hydropower resources survey within 3 years and do good planning for several 10 hydropower base areas in trying to prepare preliminary designs for 25,000 MW in hydropower stations before 1981." "We must focus on system planning, particularly plans and designs for trunklines to transmit power associated with these hydropower base areas, which should be prepared in advance." When approving and passing on this implementation program, the State Council clearly pointed out that "the electric power industry is the vanguard of the national economy. The present power shortage has prevented utilization of about 20 percent of China's industrial production capacity. For a definite period into the future, the electric power industry will continue to be a weak link in our national economy as well as an important sector which should be developed in readjustment of the national economy. All provinces, municipalities, and autonomous regions should show concern for and support development of the electric power industry and try in every way to push forward with power."

Based on this spirit and requirements, the former Ministry of Electric Power Industry Planning Department organized hydropower survey, design, and construction units throughout China to compile "Tentative Ideas for Developing 10 Large Hydropower Base Areas" which included plans for 10 large hydropower base areas on the upper reaches of the Huang He, Hongshui He on the Nanpan Jiang, Jinsha Jiang, Yalong Jiang, Dade He, Wu Jiang, the upper reaches of the Chang Jiang (including the Qing Jiang), the middle reaches of the Lancang Jiang, and in west Hunan, Fujian, Zhejiang, and Jiangxi with a total installed generating capacity of 170,000 MW. To clarify tasks for the future, they next compiled the "Situation Outline for 20 Large Hydropower Stations" (abbreviated below as the "Outline") which considered certain hydropower stations among a group of 20 large hydropower stations for which construction conditions at that time were not ready in the short term. This added five hydropower stations with rather superior conditions, so actually 25 large hydropower stations were proposed then (Table 1 lists the names, installed generating capacities, and other data for these power stations) as goals of struggle for future construction by hydropower departments.

Table 1. Comparison of Scale and Current Situation at 20 Large Hydropower Stations

	Scale				Current situation			
Name of hydropower station	Installed generating capacity (10,000 kW)	Total investment (100 million yuan)	Year and month when construction started	Year and month when power is generated	Installed generating capacity (10,000 kW)	Total investment (100 million yuan)	Year and month when construction started	Year and month when power is generated
Total	2978.5-3018.5	263.96						
1. Wujiangdu	63	6.2	1974	1979	63	5.88	1974	1979.12
2. Dahua	40	4.96	1975.10	1981	40	6.28	1975.10	1983
3. Gezhouba	271.5	35.60	1970.12	1981.7	271.5	48.48	1970.12	1981.12
4. Baishan	90	6.30	1976.5	1983	90.0	9.10	1976.5	
5. Longyang Gorge	150	9.50	1976	1983	128.0	17.79	1976	1986
6. Ankang	80	8.0	1975	1985	80.0	14.30	1975	1989
7. Dong Jiang	50	4.05	1978.10	1983	51.04	8.90	1978.10	1987
8. Wan'an	50	4.20	1979	1985	40.0	7.85	1979	1989
9. Tongjiezi	60	7.60	1979	1985	60.0	11.70	1979	1989
10. Lubuge	60	6.00	1978	1985	60.0	8.88	1978	1988
11. Tianshengqiao second cascade	80	7.20	1982	1985	88.0	14.17	1982	1990
12. Wuqiang Xi	150	12.5	1980	1986	120.0	13.39	1987	1995
13. Shuikou	140	13.0	1980	1987	140.0	18.18	1985	
14. Longtan	300	24.0	—	—				
15. Dateng Gorge	120	12.0	—	—				
16. Yantan*	120-150	12.9	1981-82	1985-86	121	16.32	1984	1995
17. Jinping*	150	10.0	—	—				
18. Ertan*	300	23.2	—	—	330	37.0	1987	1999
19. Lijia Gorge*	150	10.6	1981	1987	160	16.63	1987	1995
20. Manwan*	90	9.6	1981	1986	125	10.3	1985	
21. Geheyan	100	8.0	—	—	120	13.39	1987	1995
22. Heishan Gorge	150	9.4	—	—				
23. Pengshui	110	9.25	—	—				
24. Baozhusi	64	6.0	—	—	70	9.38	1984	
25. Mianhuatan	40-50	4.0	—	—				

Notes: (1) Stations labeled with "*" are the five large-scale hydropower stations added to the 20 large hydropower stations. (2) Heishan Gorge represents the Xiaoguanyin high dam or Daliushu high dam. (3) The investments in plan data for Gezhouba Hydropower Station do not include four 125 MW generators. They are included in the current situation

At the time, the 25 large hydropower stations listed in the "Outline" had a total installed generating capacity of about 30,000 MW, guaranteed power output of 8,740 MW, and yearly power output of up to 140 billion kWh. The total investment was 26.4 billion yuan and it would require total earthworks of 213 million cubic meters, 72 million cubic meters of concrete, resettlement of 833,000 people, and flooding 790,000 mu of cultivated land. Most of these 25 large hydropower stations had superior construction conditions, appropriate scales, good kinetic and economic indicators, and urgent power demand in nearby regions. They had advantages of small investments, limited engineering, small inundation losses, and so on. The conditions were especially good for several hydropower stations on the upper reaches of the Huang He, Hongshui He, and Yalong Jiang. Construction of 11 of these 25 large hydropower stations had already begun at that time. This group had an installed generating capacity of almost 10,000 MW, guaranteed output of 2,650 MW, and yearly power output of 43 billion kWh. The investment cost was 9.961 billion yuan, an average investment of almost 1,000 yuan per kW and a unit power investment of just 0.23 yuan per kWh. Actually, the "Outline" can be seen as a plan for building large hydropower stations in China at that time whose implementation would push hydropower construction in China a big step forward.

II. Construction Situation

Ten years have passed since the "Outline" was prepared in 1979. Seven hydropower stations, the Wujiangdu, Gezhouba, Baishan first period, Dahua, Longyang Gorge, Dong Jiang, and Lubuge projects, included in the "Outline" have now gone into operation or partial operation, with a total installed generating capacity of 6,180 MW. Installation at Gezhouba Hydropower Station, with an installed generating capacity of 2,715 MW, has now been completed and it has become the biggest hydropower station of the medium-scale hydropower stations now completed in China. Wujiangdu Hydropower Station is the first large hydropower station built in China's Guizhou region, an area of extremely developed karst. It has opened the road to future construction of large and extra-large hydropower stations in this type of region. Longyang Gorge Hydropower Station is China's first big hydropower station built in a high, frigid region. It has a perennial regulation reservoir with a capacity of 26.8 billion cubic meters and its completion has created excellent conditions for developing hydropower resources on the upper reaches of the Huang He. Baishan Hydropower Station has the largest underground plant building in China (121.4 meters long, 25 meters wide, and 54.3 meters high). It has created valuable experience for construction of large underground plant buildings in China. Lubuge Hydropower Station is the first window of successful utilization of foreign capital among large hydropower stations built in China since implementation of the policies of reform and opening up. The "Lubuge shock" has profoundly affected economic construction throughout China. Moreover, construction has begun or preparations for construction are under way for 12 big hydropower stations at Ankang, Wan'an, Tongjiezi, Tianshengqiao No 2 cascade, Wuqiang Xi, Shuikou, Yantan, Ertan, Lijia Gorge, Manwan, Geheyan, and Baozhusi with a total installed generating capacity of 14,540 MW (based on the most recent capacity estimates). These include seven hydropower stations larger than 1,000 MW. Ertan Hydropower Station will have an installed generating capacity of 3,300 MW, making it another extra-large hydropower station built after Gezhouba Hydropower Station. Successive construction starts at these hydropower stations will further raise technical levels in hydropower construction in China. For various reasons, construction of six hydropower stations has not yet begun at Longtan, Dateng Gorge, Heishan Gorge (or Daliushu), Jinping, Pengshui, and Mianhuatan, with a total installed generating capacity of about 8,800 MW. Calculated on the basis of 25 hydropower stations, the achievement rate for the number of stations where construction has begun in the past 10 years is 76 percent and the achievement rate based on total installed generating capacity is 66 percent. Calculated on the basis of 20 these rates are, respectively, 93 and 95 percent. Besides the 25 hydropower stations originally planned, construction or preparations for construction have begun at Jinshuitan in Zhejiang (300 MW), Shaxikou in Fujian (300 MW), Panjiakou in Hebei (290 MW), Baishan second stage in Jilin (600 MW), Dongfeng (510 MW) and Tianshengqiao first cascade (1,200 MW) in Guizhou, the Shisanling Pumped Storage Power Plant in Beijing (800 MW), and the Guangzhou Pumped Storage Power Plant in Guangzhou (1,200 MW). These eight large hydropower stations have a total installed generating capacity of 5,200 MW. Data for the 25 hydropower stations originally planned are listed in Table 1.

In summary, it is apparent that most of the 25 large hydropower stations included in the 1979 plan conform to actual needs and can be achieved. During the plan compilation process, it was discovered that among the 20 large hydropower stations, including Heishan Gorge (Daliushu), Longtan, Dateng Gorge, Pengshui, Mianhuatan, and other hydropower stations, it has not been possible to begin construction due to relations with adjacent provinces. In consideration of the degree of urgency in demand for power in those regions, however, construction must begin. They have not been removed from the plan list in order to push forward with the start of construction as much as possible. Instead, projects to fill the vacancies have been added. Five large hydropower stations at Yantan, Jinping, Ertan, Lijia Gorge, and Manwan were added to fill the vacancies at that time. To date, construction or preparations for construction have begun at four of these hydropower stations. This shows that the considerations and arrangements at that time also were appropriate.

III. Experience and Lessons

Valuable experiences and lessons were gained in planning and building the big group of large hydropower stations described above. I will now offer some preliminary personal views on a few points.

A. Sites Must Be Selected According to National Strengths and Feasibility

China is extremely rich in hydropower resources and we have many sites where large hydropower stations could be built. However, in deciding which hydropower stations to build first and which hydropower stations to build later, we cannot simply look at power use requirements and hydropower resource development conditions. Instead, we must look at whether or not our national strengths can bear the burden, especially after implementing pluralism in the electric power industry, and we must consider a province's or larger region's ability to raise the funds. Among the 25 large hydropower stations originally planned for construction, we have basically begun construction of all power stations under 1,000 MW and we have added several hydropower stations under 1,000 MW not included in the original plan. Most hydropower stations where construction has not yet begun are larger than 1,000 MW. Past conditions show that a single province or region cannot build more than a few hydropower stations larger than 1,000 MW at the same time. Sichuan, for example, had just begun building Tongjiezi and Baozhusi Hydropower Stations when it immediately wanted to

build Ertan Power Station with an installed generating capacity of 3,300 MW. It is now experiencing difficulties and will be unable to build Jinping Hydropower Station at the same time. Other examples are Guangxi, Guizhou, and other provinces now building the Tianshengqiao second cascade, Yantan, Tianshengqiao first cascade, Dafeng, and other large hydropower stations. It is unlikely that they will be able to begin building Longtan and Dateng Gorge Hydropower Stations at the same time. It is another matter, of course, if neighboring provinces need the power and are willing to invest in construction. In summary, we cannot look merely at demand but should instead consider possibilities in terms of manpower, materials, and financial strengths.

B. Local Enthusiasm for Building Hydropower Stations Must Be Considered

Construction starts over the past 10 years at several big hydropower stations proceeded to a substantial extent by relying on local initiative. Local areas are willing to build hydropower stations as quickly as possible when they come to understand energy resource supply difficulties and hydropower's advantages. They make hydropower station construction an important aspect of work in their province or autonomous region. In this situation, problems like inadequately funded preparatory work, delays in preparatory work, substantial difficulties in resettlement work, difficulties in raising capital, and so on can be solved more quickly. The start of construction at Shuikou, Yantan, Ertan, Lijia Gorge, Manwan, and Geheyan hydropower stations was pushed forward in this manner over the past few years. After construction got under way at these power stations, local areas strengthened leadership and established power station construction leadership groups to organize powerful construction leadership organs and the projects progressed smoothly. In contrast, if local enthusiasm is low, construction may stop once it has begun despite the demand for power and very good conditions. Such repetition occurred in building Wuqiang Xi and Baozhusi Hydropower Stations, which has wasted time. Moreover, there are always gains and losses in construction. It is impossible to have gains but no losses. Besides funding problems in hydropower construction, resettlement and land inundation are major problems which can affect accelerated hydropower construction. Thus, plans and designs should try to reduce resettlement and land occupation, and they should reluctantly give up some interests. There is an extremely tight relationship between large hydropower station construction and local areas. Future hydropower plans certainly should listen more to local views and fully motivate local initiative to develop hydropower.

C. Consideration Must Be Given to Whether or Not Unanimous Agreement Can Be Obtained for Hydropower Station Construction Programs on Inter-Provincial Boundaries

Many of the 25 large hydropower stations are located on boundaries between provinces. They involve much more complex relationships than hydropower stations sited in one province or autonomous region. Those include the completed Lubuge Hydropower Station and Tianshengqiao second cascade hydropower station now under construction on the Yunnan-Guizhou border, and the Tianshengqiao first cascade hydropower station where preparations for construction are now under way, which will affect Yunnan, Guangxi, and Guizhou. The inter-provincial relationships for these hydropower stations have been handled rather well and the projects are proceeding rather smoothly. However, for the six hydropower stations where work has not begun, excluding Jinping Hydropower Station, the other five big hydropower stations at Longtan, Dateng Gorge, Heishan Gorge (or Daliushu), Pengshui, and Mianhuatan are located at provincial boundaries, and there have been continual bipartisan disputes concerning the dam sites, power station locations, normal water storage levels, and other questions which remain unsolved after a long period of time. This has wasted considerable manpower and materials on the survey designs and demonstration work for implementing various programs. The problem was not that this issue was not understood at the time of planning. Instead, the problem was that these power stations were very important, both in terms of their own benefits as well as their role in cascade development of the entire river. Thus, I hope that these hydropower stations can be developed soon and bring prosperity to the relevant provinces and autonomous regions, and I feel that disputes can always be settled satisfactorily. However, things can go contrary to one's wishes, and 10 years have passed without a resolution. The most intense debate concerns development programs for the Heishan Gorge segment in the upper reaches of the Huang He. It has lasted over 30 years and continues without conclusion even today. Construction programs for many big hydropower stations on provincial boundaries have become perennial headaches. I feel that the state cannot allow this type of phenomenon to exist and should stop the disputes when they have reached a certain limit. In future hydropower plans, hydropower stations on provincial boundaries should not be included in long-term hydropower plans if agreement has not been reached.

D. Fully Consider Realistic Project Feasibility

For the 25 large hydropower stations, beginning with the need for power, building Pengshui Hydropower Station on the Wu Jiang can provide power for use locally in east Sichuan and it can improve shipping channels in the lower reaches of the Wu Jiang. Building Mianhuatan Hydropower Station could provide power locally to south Fujian and east Guangdong and, in conjunction with water conservancy and hydropower project facilities on the trunk of the Han Jiang in Guangdong Province, it could reduce the danger of flooding on the Han Jiang delta. The reservoir backwater would extend to Dahang and Yongding and shipping channels within the scope of the reservoir would be improved. The passage of large vessels would not be obstructed, which would aid development of the mountainous region in south Fujian.

Building Jinping Hydropower Station could provide electricity to west Sichuan. All these things are extremely ideal. However, because of a failure to consider the complexity and realistic feasibility of the projects during planning, the conditions to begin construction have not existed for the past 10 years. Thus, when formulating hydropower plans, we certainly must consider the realistic feasibility of the projects. Generally speaking, it is better if they are included in long-term construction plans after feasibility research is completed and the project proposal is examined and approved. However, once they are included in long-term construction plans, a decision must be made to reinforce preparatory work and complete the survey design as quickly as possible to create the conditions required to begin project construction.

E. There Must Be Completely Reliable Foresight

The "Outline" compiled in 1979 lacked an understanding of building large pumped storage power stations, transformation and expansion of existing hydropower stations, and other questions. Substantial breakthroughs have been made in these two areas over the past 10 years. Examples include building Panjiakou pumped storage power station, the rapid start of construction at the Guangzhou pumped storage power station and Shisanling pumped storage power station, and completion of the feasibility research report and formulation of agreements in principle by the relevant provinces and municipalities concerning capital raising measures for an even bigger pumped storage power station at Tianhuangping. We have now begun to understand that building pumped storage power stations in economically developed regions of east China with limited water resources is necessary as well as economically rational. Similarly, our understanding of expansion of existing hydropower station has improved. Examples include the second stage expansion immediately after completion of the first stage project at Baishan Hydropower Station, and the expansions of Shuifeng, Fengman, Yanwo Gorge, and other hydropower stations. These were not expected at the time the 1979 plan was prepared. Future hydropower plans must have several truly reliable hydropower station projects and they require scientific foresight and ideas to promote further development of hydropower construction. A problem now appearing for the first time is "transmitting power from west China to east China." Examples include linking the northwest and north China grids and accelerating hydropower resource development on the upper reaches of the Huang He in west China to transmit power to the north China region; linking the southeast, south-central, and east China grids and developing the Three Gorges Hydropower Station and Xiangjiaba and Xiluodu Hydropower Stations on the Chang Jiang to transmit power to south-central and east China; and linking the southwest and south China grids and developing extra large hydropower stations on the Hongshui He, Wu Jiang, and Lancang Jiang to transmit power to south China, which has an energy resource shortage. These problems require scientific foresight in plans and gradual solutions.

F. Use Hydropower Base Areas as the Main Factor While Also Considering Other Regions

China's large conventional hydropower stations are concentrated mainly in 10 large hydropower base areas. The focus of these 10 large hydropower base areas is development of the upper reaches of the Huang He, the trunk and tributaries of the middle and upper reaches of the Chang Jiang, Hongshui He, Wu Jiang, and Lancang Jiang. However, in terms of economic development and power use requirements in China, the most urgent task in power source construction continues to be solving the power use problems of China's east coast. Moreover, for conventional hydropower stations, east China lacks resources, but the situation is just unfolding for building pumped storage power stations. Thus, we should make hydropower base areas the main factor when implementing hydropower base area plans while also giving consideration to other regions. In the 1979 plan, although arrangements were made to build three large hydropower stations at Baishan (900 MW), Ankang (800 MW), and Shuikou (1,400 MW) outside of the coast and base area regions, these are not enough. Of the eight large hydropower stations added outside of plans over 10 years, with the exception of Dongfeng Hydropower Station, the other seven were distributed along coastal regions. This shows fully that inadequate attention was given to other regions outside the base areas in the plans.

G. Adequate Attention Must Be Given to Preparatory Work

The construction situation for the 25 large hydropower stations shows that construction of many projects could not begin as scheduled due to backward preparatory work. Poorly done preparatory work for several projects has meant that new problems appeared after work began, which affected project progress. Designs were revised during the construction process at Gezhouba, Longyang Gorge, Tongjiezi, and other hydropower stations. Restudy after the start of construction at Wan'an and Wuqing Xi Hydropower Stations led to a lowering of the normal water storage level. Dam sites were switched after the designs were completed for Pengshui and Mianhuatan Hydropower Stations, and so on. The experiences and lessons of these examples should be conscientiously summarized. The backwardness of preparatory work for hydropower is especially apparent at the present time. Project construction documents have been approved for only one of the large and medium-scale hydropower station projects whose start of construction is planned for the Eighth 5-Year Plan. The situation faced by survey and design units is that on the one hand, preparatory work is very backward and cannot meet the needs of construction and development and, on the other hand, there is forced idleness in hydropower survey and design staffs due to poor organization. They are forced into diversifying their activities and orienting toward society. The key problem is inadequate experience in

preparatory work. For this reason, it would be best to adopt the method of raising capital for preparatory work and compensated application of hydropower preparatory work achievements, including survey and design costs in hydropower project budgets, with a return of control to the state after construction begins for use in continued expansion of preparatory work for hydropower stations.

H. Attention Should Be Given to Shortening Construction Schedules and Reducing Construction Costs

Table 1 compares plans and the current situations for the 25 hydropower stations. Startup dates for hydropower stations where construction has already begun are often delayed and there are delays in the dates of construction starts and operationalization for hydropower stations where construction has not begun. Construction costs for hydropower stations have risen very quickly over the past few years due to inflation and increased costs. This must receive our attention. To accelerate hydropower construction, the state should increase its investments in hydropower construction and we should use hydropower construction funds well to make full use of the benefits. Large total investments and long construction schedules are prominent weaknesses of large-scale hydropower stations. We should focus on shortening capital construction schedules and formulating construction standards which conform to economic construction conditions in China at the present time. Excessively high standards should be reduced to achieve a true reduction in construction costs, save raw materials, and increase labor productivity.

IV. Tentative Ideas for the Future

In summary, one can see that preliminary plans in the "Outline" formulated in 1979 played a definite role in guiding and promoting large-scale hydropower station construction over the past 10 years. For this reason, we should summarize experiences and lessons as a basis for formulating hydropower construction plans for the next 10 years. These are my preliminary ideas: start building an additional 45,000 MW in large hydropower stations over the next 12 years and place 32,000 MW of large hydropower stations, 10,000 MW of medium-scale hydropower, and 8,000 MW of small-scale hydropower into operation. On the basis of the relevant plan and design data, my preliminary idea is to build 40 large hydropower stations over the next 12 years (see Table 2). Divided according to region, it calls for four stations with 3,500 MW in north China, three stations with 1,910 MW in northeast China, six stations with 4,400 MW in east China, 10 stations in south-central China with 9,940 MW, 10 stations with 16,630 MW in southwest China, and seven stations for 8,860 MW in northwest China. Divided according to hydropower base areas, they would involve six stations for 8,460 MW in the base area in the upper and middle reaches of the Huang He, three stations for 1,600 MW in the Fujian-Zhejiang-Jiangxi base area, two stations for 6,000 MW in the Hongshui He base area, three stations for 1,090 MW in the west Hunan base area, one station for 1,000 MW in the middle reaches of the Chang Jiang (including Qing Jiang) base area, two stations for 1,900 MW in the Yalong Jiang base area, one station for 3,300 MW in the Dadu He base area, four stations for 4,580 MW in the Wu Jiang base area, and three stations for 6,850 MW in the Lancang Jiang base area. There would be a total of 25 large hydropower stations with 34,780 MW in the base areas, equal to about 77 percent of the 45,240 MW in 40 stations. Divided according to capacity, there would be 14 large hydropower stations over 1,000 MW for 30,590 MW, equal to 67.6 percent of the total capacity. There would be 26 stations at 1,000 MW and less for a total of 14,650 MW, equal to 32.4 percent of total capacity. Divided according to type of power station, there would be 34 conventional hydropower stations for a total of 39,440 MW, equal to 87.2 percent of the total, and six pumped storage power stations with a total of 5,800 MW, equal to 12.8 percent of the total.

Table 2. Brief Description of 40 Large Hydropower Stations for 1991-2000

Region	Names of 10 large hydropower base areas	Names of hydropower stations	Capacity of 10 large hydropower base areas (10,000 kW)	Total (10,000 kW)
North China	Upper and middle reaches of the Huang He	Wanjiazhai (1,080 MW), Longkou (420 MW)	150	350
	Other	Zhanghewan* (1,000 MW), Wuling Shan* (1,000 MW)		
Northeast China		Qingshiling* (1,000 MW), Songjiang He (510 MW), Sanjianfang (400 MW)	—	191
East China	Fujian-Zhejiang-Jiangxi	Jiemian (400 MW), Tankeng (600 MW), Mianhuatan (600 MW)	160	440
	Other	Tianhuangping* (1,800 MW), Langya Shan* (400 MW), Da He* (600 MW)		

Table 2. Brief Description of 40 Large Hydropower Stations for 1991-2000 (Continued)

Region	Names of 10 large hydropower base areas	Names of hydropower stations	Capacity of 10 large hydropower base areas (10,000 kW)	Total (10,000 kW)
South-central China	Hongshui He	Longtan (5,000 MW), Dateng Gorge (1,000 MW)	600	994
	West Hunan	Jiangya (400 MW), Dong Jiang generator expansion (420 MW) Wanmipo (270 MW)	109	
	Middle reaches of the Chang Jiang	Shuibuya (1,000 MW)	100	
	Other	Pankou (510 MW), Huanglongtan (310 MW), Xinfeng Jiang expansion (300 MW), Changzhou (700 MW)		
Southwest China	Yalong Jiang	Jinping second cascade (1,500 MW), Tongziling (400 MW)	190	
	Dadu He	Baobugou (3,300 MW)	330	1663
	Wu Jiang	Goupitan (2,000 MW), Hongjiadu (540 MW), Pengshui (1,200 MW), Silin (840 MW)	458	
	Lancang Jiang	Xiaowan (3,000 MW), Dachao Shan (1,250 MW), Nuozhadu (2,600 MW)	685	
Northwest China	Upper and middle reaches of the Huang He	Laxiwa (3,720 MW), Gongbo Gorge (1,500 MW), Heishan Gorge (1,440 MW), Daxia (300 MW)	696	886
	Other	Xunyang (300 MW), Miaojiaba (1,200 MW), Jilintai (400 MW)		
Total		40 hydropower stations	3478	4524

Notes: (1) Among the hydropower base areas on the middle reaches of the Chang Jiang, the Three Gorges Hydropower Station has obvious benefits, an appropriate location, good development conditions, and full preparatory work. The time of its construction must be arranged as state investments permit, so it is not included in the table. (2) This table does not include hydropower stations at water conservancy projects or hydropower stations on the Heilong Jiang at the Sino-Soviet border. (3) Stations labeled with an "*" in the table are pumped storage power stations. There are six altogether, for 5,800 MW. (4) This table does not include Ertan and Tianshengqiao first cascade hydropower stations or Shisanling pumped storage power station for which preparations for construction are under way.

Hydropower construction in China now faces an extremely serious situation. To enable acceleration of large hydropower station development, we must further reform the management system, increase inputs, and formulate policies favorable to hydropower development. The enormous achievements and advances toward modernization in hydropower construction in China over the 40 years since the nation was founded give us full confidence that within the next 10-plus years, we certainly will be able to push hydropower construction toward an even greater high tide.

Table 3. Brief Description of Some of China's Pumped Storage Power Stations

Name of power station	Installed generating capacity (10,000 kW)	Startup type	Project situation
Guangzhou, Guangdong	4 x 30	Silicon controlled frequency conversion + back-to-back	In technical execution design
Tianhuangping, Zhejiang	6 x 30	Silicon controlled frequency + back-to-back	In preliminary design
Shisanling, Beijing	4 x 20	Silicon controlled frequency conversion + back-to-back	In technical execution design

Table 3. Brief Description of Some of China's Pumped Storage Power Stations (Continued)

Name of power station	Installed generating capacity (10,000 kW)	Startup type	Project situation
Panjiakou, Hebei	1 x 15 + 3 x 9*	Silicon controlled frequency conversion + back-to-back	In generator installation
Xiwan, Jiangsu	4 x 3.75	Step-down asynchronous	In feasibility design
Qingshi Shan first stage, Jiangsu	2 x 6	Step-down asynchronous	Feasibility report completed
Langya Shan, Anhui	4 x 10	Asynchronous electric motor	Feasibility report completed
Xianghongdian, Anhui	4 x 1 + 2 x 5.5*	Back-to-back	Feasibility report completed
Miyun, Beijing	4 x 1.5 + 2 x 1.5*	Step-down asynchronous	In operation
Gangnan, Hebei	2 x 1.5 + 1 x 1.5*	Step-down asynchronous	In operation
Yangzhuoyong Hu, Tibet	4 x 2	Water turbine startup	Construction of water conversion project, feasibility design for generator plant building

Notes: (1) For stations labeled with an "*," the figures before the + sign are conventional, the figures after the + sign are pumped storage. (2) Statistics taken from SHUILI SHUIDIAN KANCE SHEJI QINGBAO DONGTAI [TRENDS IN WATER CONSERVANCY AND HYDROPOWER SURVEY AND DESIGN INFORMATION], No 1, 1989

Medium-Sized Hydropower Stations: Achievements and Prospects

906B0015F Beijing SHUILI FADIAN [WATER POWER] in Chinese No 10, 12 Oct 89 pp 68-70

[Article by Kuang Jianfu [0562 1696 1133] of the State Energy Resource Investment Company: "China's Achievements and Prospects in Medium-Scale Hydropower Construction"]

[Text] China's medium-scale hydropower station construction has developed substantially in the 40 years since the nation was founded. In 1949, we had only one medium-scale hydropower station (Jingbo Hu Heilongjiang Province) with an installed generating capacity of 36 MW. By the end of 1989, we expect to have completed 101 medium-scale hydropower stations with 6,780 MW in installed generating capacity, 188 times the 1949 figure, which is a major accomplishment. China's medium-scale hydropower stations generated 23 billion kWh of power in 1987, 78 percent of it in southern provinces. Especially noteworthy are nine southern provinces with coal shortages (Table 1). They have 60 medium-scale hydropower stations which generate a total of 16.2 billion kWh of power, equivalent to substituting for nearly 10 million tons of coal, about one-fifth the net in-shipments of raw coal into these nine provinces and autonomous region during 1987. Of the 60 medium-scale hydropower stations mentioned above, 57 participate in unified grid dispatching and account for 17.8 percent of unified dispatching capacity and 14 percent of power output. Obviously, medium-scale hydropower plays a positive role in reducing coal and power shortages in these regions.

Table 1. Proportion of Medium-Scale Hydropower in Grid Dispatching for Nine Southern Provinces, 1987

	Unified dispatching in grids		Medium-scale hydropower		Proportion in medium-scale hydropower (percent)		
Province or autonomous region	Equipment capacity (10,000 kW)	Power output (100 million kWh)	Capacity (10,000 kW)	Power output (100 million kWh)	Capacity	Power output	Net in-shipments of raw coal (10,000 tons)
Zhejiang	319.5	146.5	22.5	6.2	7.0	4.2	1108
Fujian	141.2	63.5	58.9	21.2	41.7	33.4	324
Jiangxi	174.2	83.2	31.3	8.4	18.0	10.1	296
Hubei	499.0	236.6	26.4	11.3	5.3	4.8	1658
Hunan	245.7	120.1	31.0	12.8	12.6	10.6	481
Guangdong	222.4	121.8	43.7	11.4	19.6	9.4	807
Guangxi	162.8	75.8	48.5	21.1	29.8	27.8	294
Sichuan	383.0	198.8	75.2	32.3	19.6	16.2	92
Yunnan	154.6	73.4	72.7	31.6	47.0	43.0	40
Total	2302.4	1119.8	410.2	156.3	17.8	14.0	5100

Beginning in the 1950's, we implemented the methods of comprehensive river basin planning, continuous cascade development, construction while water is flowing, and accomplishing something without interruption. We achieved very good economic results and accumulated rich experience for hydropower development. Development of medium-scale hydropower stations in China has substantially improved local design and construction forces and technical levels. Local areas are now responsible for designing and building most medium-scale hydropower stations in China.

The scientific experiments, technical innovations, and engineering practice we have implemented in medium-scale hydropower station construction over the past 40 years have helped us overcome many technical problems and make gratifying achievements. Examples include directional blasting for dam structures, using rollers to compress concrete for dam building, building concrete faced stone-fill dams, foundation processing, and other technologies. All these things were first tested and applied in medium-scale hydropower station projects.

In the area of electromechanical equipment manufacturing, mutual support and mutual promotion by our machinery manufacturing departments have brought continually improved technical levels, sustained reinforcement of equipment production, and innovation and strengthening in manufacturing plants which produced small hydropower generators in the past. They have now become key plants in medium-scale hydropower equipment production and created conditions for major efforts to develop medium-scale hydropower in the future.

Although medium-scale hydropower has developed substantially over the past 40 years and made many achievements, there would appear to be a lack of matchup given that China has 67,000 MW in medium-scale hydropower resources but also has severe shortages of coal and electric power at the present time. The medium-scale hydropower capacity placed into operation in each construction period since the nation was founded (Table 2) shows that development has been very uneven. This is especially true since the mid-1970's, which saw an abrupt drop in medium-scale hydropower capacity placed into operation. During the Fourth 5-Year Plan, 2,420 MW of medium-scale hydropower went into operation, the peak amount since the nation was founded. This declined to 1,450 MW during the Fifth 5-Year Plan and again to 450 MW during the Sixth 5-Year Plan. Why has there been a sustained drop in medium-scale hydropower capacity placed into operation and why has it decreased so much? I think the main reasons are: 1) The state has lacked industrial policy guidance and support in a situation of financial shortages, especially in the late 1970's. After dividing finances into central finances and local finances, the state did not immediately formulate specific industrial policies to guide the direction of capital investments and enable them to benefit medium-scale hydropower development. 2) The state did not formulate the necessary preferential policies to support local areas in building medium-scale hydropower like those to support local coal mines. 3) Coal and electricity prices were irrational and there was severe distortion of prices and value. Cheap coal hurt hydropower and obscured the advantages of hydropower and conserving coal. Low electricity prices affected hydropower station incomes and repayment abilities. All these things hurt local initiative to develop medium scale hydropower.

Table 2. Medium-Scale Hydropower Capacity Placed Into Operation During Each Construction Period

Period	Total hydropower capacity placed into operation (10,000 kW)	Small-scale hydropower capacity placed into operation (10,000 kW)	Small-scale hydropower as a proportion (percent)
1950-1952	2.5	—	—
First 5-Year Plan, 1953-1957	83.1	16.5	19.8
Second 5-Year Plan, 1958-1962	135.9	56.1	41.[illegible]
Three years of readjustment 1963-1965	64.1	17.3	27.[illegible]
Third 5-Year Plan, 1966-1970	321.5	85.3	26.[illegible]
Fourth 5-Year Plan, 1971-1975	719.3	242.7	33
Fifth 5-Year Plan, 1976-1980	689.0	145.1	[illegible]
Sixth 5-Year Plan, 1981-1985	609.7	45.5	[illegible]
First 3 years of Seventh 5-Year Plan 1986-1988	628.0	54.2	8

The decline in medium-scale hydropower capacity placed into operation has attracted concern and attention in the hydropower system and planning and policy-making departments. In a 1984 report to central authorities, the former Ministry of Water Resources and Electric Power called for the state to formulate preferential policies to support local medium-scale hydropower development efforts. The China Hydroelectric Power Engineering Society also held a symposium on accelerating development of medium-scale hydropower to suggest ways and means for the state. While formulating the Seventh 5-Year Plan, the State Planning Commission decided to begin allocating 200 million yuan in investments each year starting in 1987 and to invest a fixed sum to support local medium-scale hydropower development. Simultaneously, many local areas debated ways

to accelerate medium-scale hydropower development. To reduce its coal shortage and meet the need to develop an export oriented economy, Fujian Province made bold reforms and broke down industry boundaries with approval by the provincial government in 1985. The Fujian Provincial Electric Power Bureau, Jiangle County, and Min Jiang Hydropower Engineering Bureau jointly invested in building Fancuo Hydropower Station. A board of directors was organized from each of the parties raising capital and they established the Fancuo Hydropower Station Co., Ltd. Quanzhou City, Yongchun County, Dehua County, and the Fujian Provincial Hydropower Department jointly invested in building Longmentan Hydropower Station, organized a board of directors composed of all parties which raised capital, and established the Longmentan Water Diversion Project Development Company. These two hydropower stations implemented a principle of unified construction, management, and utilization, and integrated responsibilities, rights, and benefits. This motivated local initiative to raise capital to develop power. When it approved these two projects, the Fujian Provincial Government clearly stipulated preferential policies. They provided appropriate investment subsidies during the construction period based on economic conditions in the areas where the projects were located, they subsidized evaluation of "three materials" standards for capital raised by prefectures and counties themselves, and they reduced the cultivated land occupation tax for projects which provided flood prevention, irrigation, and other water conservancy benefits. When the projects are completed and begin operating, they are treated the same as small-scale hydropower, meaning that they are exempted from product taxes for 3 years and are subject to product taxes of only 5 percent after 3 years. They have 10 to 12 years to repay the capital and interest, and they implement floating prices for electricity set once each year. At the end of 1985, Hunan Province raised construction capital at the provincial, prefecture, and county levels and approved the resumption of construction of two medium-scale hydropower stations at Sanjiangkou and Yaotian, which originally had received their construction investments from the state and had stopped construction in 1979. Next, Sichuan Province adopted the method of everyone raising capital to build several medium-scale hydropower stations. According to incomplete statistics, all areas of China are using various arrangements to build more than 30 medium-scale hydropower stations at a construction scale of about 1,500 MW. Projections are that the medium-scale hydropower capacity placed into operation during the Seventh 5-Year Plan will be double that in the Sixth 5-Year Plan. There is now a great clamor for building medium-scale hydropower stations and many localities are formulating plans, raising capital, handling project establishment procedures, and preparing to start construction. There is great enthusiasm and the size of the construction scale is unprecedented. Thus, we can expect substantial development of medium-scale hydropower stations over the next 10 years. The main foundations are:

1. The Serious Energy Resource Situation Has Compelled Acceleration of Medium-Scale Hydropower Development

China now has a serious energy resource situation. Coal-fired thermal power now provides about 70 percent of our electric power output, so it is the main factor in electricity production. For this reason, the rate of growth in coal output directly affects development of the electric power industry. China's coal-fired thermal power plants burned a total of 246 million tons of raw coal in 1988 for power generation and heat supplies. This was about one-fourth of raw coal output in 1988. Energy resource department plans call for raw coal output of 1.4 billion tons in the year 2000, a net increase of 400 million tons over 10 years. Because there are a wide range of uses for coal which concern industrial and agricultural production and the people's daily lives, we cannot use the greatest portion of it to generate electricity. There are direct restrictions on developing this type of thermal power. While listening to reports on energy resource work, State Council member Zou Jiahua [6760 1367 5478] pointed out repeatedly that electric power development in the year 2000 cannot depend entirely on coal-fired power, but must instead also depend on hydropower. The principle for developing power is "combining hydropower and thermal power, adapting to local conditions." Hydropower development should involve large, medium, and small-scale projects. Development of medium-scale hydropower should depend mainly on local areas. In its "Medium Term (1989-2000) Development Plan Program for China's Energy Resource Industry," the Ministry of Energy Resources used the need for a nation balance in energy resources as a foundation for proposing that we try to place 10,000 MW in medium-scale hydropower into operation in China before 2000. The goals of struggle proposed by the central leadership and energy resource development programs will certainly promote the development of medium-scale hydropower.

2. The Electric Power System Now in Place Will Promote Medium-Scale Hydropower Development

Over the past few years, an electric power system of "separation of government and enterprises, provinces as the main factor, integrated grids, unified dispatching, and raising capital to develop power" has taken shape through intensive reform. The principle of multiple departments, multiple levels, and multiple forms to raise capital has been implemented in electric power construction. In electric power allocation, we have implemented a division among central enterprises and local enterprises. No longer do we have a big common pot where "the state develops power and everyone uses it." This has increased local responsibility for developing power. We began requisitioning an electric power construction fund in 1988, and we have reinforced economic strengths and control measures for local development of power, which has increased local enthusiasm for developing power. Medium-scale hydropower has advantages like short construction schedules, smaller investments,

rapid results, local initiative, ease in implementing capital raising, and so on. Thus, the present electric power system will promote medium-scale hydropower development.

3. Preferential Policies and New Management Experiences Will Promote Medium-Scale Hydropower Development

Over the past few years, Fujian, Hunan, Sichuan, and other provinces have used intensified reforms to formulate many preferential policies to accelerate medium scale hydropower development. They have adopted several measures and accumulated much experience in areas like raising capital, organizing construction, administration and management, allocating benefits, and so on, and the results have been quite good. They have broadened the path and continually invigorated medium-scale hydropower. These policies and experiences will promote further development of medium-scale hydropower.

4. Resource Advantages Provide the Conditions for Accelerating Medium-Scale Hydropower Development

China has 67,000 MW in developable medium-scale hydropower resources but only 10 percent is now being used, so there is great potential for development. This is especially true for 10 provinces: Zhejiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, and Yunnan. They have coal shortages and had net in-shipments of 51 million tons of coal in 1987. Moreover, these provinces and autonomous regions have 34,500 MW in medium-scale hydropower resources awaiting development. Although construction conditions are not very good in some of them, optimized design and careful selections can permit choosing several projects with rather good results for development at the present time.

5. The Direction of State Investments Should Support Medium-Scale Hydropower Development

Development of medium-scale hydropower depends mainly on local areas. The state also should implement industrial policies and readjust investment structures to organize investment of small amounts of capital in medium-scale hydropower to play a role in guiding investments. The State Energy Resource Investment Company, Huaneng Group Company, and other financial organs will use shares, joint investments, and other patterns to provide capital according to their own conditions and capital possibilities in accordance with the principle of selective development and competitive market mechanisms to help local areas develop medium-scale hydropower.

Looking back to the past and toward the future, I am confident that the cause of medium-scale hydropower will receive the concern of central authorities and the efforts of local areas and that with support from all departments it will overcome all types of difficulties and achieve new development.

Great Achievements Claimed for Small Hydropower Stations

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[Article by Li Ying [2621 3576] of the Ministry of Water Resources Rural Hydropower Department: "China's Enormous Achievements in Small-Scale Hydropower Construction"]

[Text] "China is first under heaven in hydropower." China is a vast country with a huge population. We have many rivers and over 50,000 river basins larger than 100 square kilometers. Survey data show that China has theoretical small-scale hydropower resource reserves of 150,000 MW which could produce 1.3 trillion kWh of power annually. This includes 75,000 MW in developable resources which could produce 250 to 300 billion kWh of power annually. China's small-scale hydropower resources are abundant and widely distributed, with 1,104 of China's 2,300-plus counties (cities) having developable resources in excess of 10 MW. The development of socialist construction in China since the nation was founded has brought enormous achievements in small-scale hydropower construction with the support of leadership at all levels and the self-reliance and arduous efforts of our people.

I. Achievements in the Past 40 Years

A. Small-Scale Hydropower Installed Generating Capacity Surpasses 10,000 MW

By the end of 1988, China had completed over 60,000 small-scale hydropower stations with an installed generating capacity of 11,790 MW.[1] This is 33 times China's total installed hydropower generating capacity in 1949 and 36 percent of China's hydropower installed generating capacity in 1988. Small-scale hydropower generated 31.6 billion kWh of electric power in 1988, equal to 30 percent of total power output from hydropower in China and 36.2 percent of rural power use in China. This was more than 26 times the power output from hydropower in China shortly after the nation was founded. The scale of small-scale hydropower now under construction in China is 3,000 MW and the development scale of small-scale hydropower has become a part of China's electric power industry which cannot be ignored.

B. One-Third of China's Counties Depend Mainly on Small-Scale Hydropower for Their Power Supplies

China's small-scale hydropower has grown gradually from single stations operated to supply power to multi-station integrated grid operation. At the end of 1988, China had 10,290 MW in small-scale hydropower linked up for integrated operation at the county-county or higher level, and many rural areas now have their own small grids. Of the 1,531 counties (cities) which have built small-scale hydropower, 717 counties depend mainly on small-scale hydropower for their power supplies, equal to about one-third of China's counties

Nearly 20,000 townships depend mainly on small-scale hydropower for their power supplies, about 36 percent of all townships in China. Regions which receive power supplies from small-scale hydropower have 68 kilometers of high voltage power lines and 1.52 million kilometers of low voltage power lines, a 110 kV power transformation capacity of 3.98 million kVA, a 35 kV power transformation capacity of 10.38 million kVA, and a 10 kV matching power transformation capacity of 30.53 million kVA which have basically formed a grid framework having a definite power supply capability. Regions which receive their power supplies from small-scale hydropower cover an area equal to about 58 percent of the total area of China. Small-scale hydropower provides power supplies for a population of about 300 million, 300 million mu of cultivated land, and nearly 800 counties. Its role is spectacular.

C. 100 Counties Have Achieved Preliminary Rural Electrification

To implement rural electrification as quickly as possible, the State Council approved the establishment at the end of 1983 of 100 trial rural electrification counties whose main source of power is small-scale hydropower on the basis of hydropower resource conditions, the power supply capacity of small-scale hydropower, and construction experiences. After 1 year of plan preparations and 4 years of implementation, a total of 48 counties had attained the standards for preliminary rural electrification counties at the end of 1988 and it is expected that all 100 counties will attain the standards for preliminary rural electrification counties by the end of 1989.

D. Installed Generating Capacity Doubled After 10 Years of Reform

After 10 years of reform, China's small-scale hydropower installed generating capacity grew from 5,266.5 MW to 11,792 MW, an increase of 124 percent. An additional 800 MW in installed generating capacity was added in 1988, almost as much as the total hydropower installed generating capacity added in China during the 10-year period before 1958. Yearly power output increased from 9.973 billion kWh to 31.61 billion kWh, an increase of 217 percent. There was 260 million kWh in additional power output in 1988, more than double the power output from hydropower in China shortly after the nation was founded. Small-scale hydropower grids also saw substantial growth over this 10-year period. High and low voltage lines expanded from 1.06 million kilometers to 2.2 million kilometers, an increase of 108 percent, and the transformation capacity grew from 19 million kVA to 44.41 million kVA, an increase of 134 percent. The proportional capacity of small-scale hydropower stations linked to grids at the county level and above increased from 41 percent to 87 percent. The average yearly utilization time of small-scale hydropower equipment in China increased from 1,948 hours to 2,820 hours, a substantial increase in economic results.

E. Technical Staffs for Small-Scale Hydropower Have Been Trained

Only a few 100 employees were involved in small-scale hydropower activities shortly after the nation was founded, but by 1988 there were 457,000 small-scale hydropower operating personnel, including 34,400 technical personnel and 402,000 operating technical personnel. There were also several 100,000 small-scale hydropower construction and installation workers. Counties in south China usually have several specialized technical personnel involved in surveying, planning, design, construction, and management. Some provinces (autonomous regions) have taken on consulting, training, and construction tasks for small-scale hydropower in foreign countries. We have accumulated rather complete experience in small-scale hydropower design, construction, production, management, and other areas. A set of strict construction examination and approval procedures have been established for power transmission and transformation projects for power stations of 500 kW and up and for 35 kV and above power transmission and transformation projects. Small-scale hydropower construction in most counties has developed in a rather rational way on the basis of unified planning. Beginning in 1985, over 1,700 station managers in key power stations and managers of county small-scale hydropower companies underwent unified state testing for enterprise directors and managers in groups at different times, and most passed the tests and met specifications. This staff with rich experience is a fundamental force for accelerating medium and small-scale hydropower construction in the future.

F. Small-Scale Hydropower Development and Technical Progress Have Attracted International Attention

Rapid development of small-scale hydropower has promoted development of power station equipment and scientific and technical progress. In equipment manufacturing, we have grown from a few product varieties to 83 product types in 26 series, and we have developed from importing equipment to equipment exports and sales to Third World nations as well as Europe, the United States, and other countries. China's nearly 100 specialized manufacturing plants can produce 1,000 MW of small-scale hydropower generators each year which can be utilized with heads of 0.5 to 820 meters and in power stations with capacities ranging from 600 W to 25 MW. Many technologies have now approached advanced world levels. Examples include substitution of automatic pressure regulating valves for pressure regulating wells, substitution of high head prestressed reinforced concrete pressure pipes for steel pipes, brushless excitation generators, automatic load regulators, microcomputer automatic monitoring and control systems, stone arch dams, rolled concrete dams, and local materials dams, prevention of steam corrosion, wear, and vibration in water turbines, optimized dispatching in cascade power stations, comprehensive utilization and development plans for seasonal power utilization and small and medium-sized rivers, and so on. Construction experience in

small-scale hydropower in particular has attracted international attention. The United Nations has held several international small-scale hydropower conferences in Hangzhou since 1980, and they established the Asia-Pacific Region International Small-Scale Hydropower Training Center in China to pass on and exchange China's experiences in small-scale hydropower construction and management. China now leads the world in number of small-scale hydropower stations built, total installed generating capacity, and yearly power output.

II. Obvious Benefits

Small-scale hydropower construction has generated enormous social benefits in the 40 years since the nation was founded, and it has brought prosperity to large numbers of peasants and obvious changes to rural areas. They mainly involve the following areas:

A. Rapid Economic Growth Has Changed the Rural Industrial Structure

In the past, the economy of mountainous areas had a weak foundation. Industry, sideline production, and processing industries developed slowly and agriculture basically dominated the industrial structure. The development of small-scale hydropower has brought life and vitality to mountainous regions and the universal availability of power has promoted economic development. The gross value of output in the 100 trial rural electrification counties where small-scale hydropower was the main source of power increased by 95.1 percent. This included a 2.26-fold increase in the value of industrial output and a 4.48-fold increase in the value of output from township and town enterprises. The value of output from industry as a proportion of the total value of output increased from 32.7 percent to 54.82 percent, which has effectively promoted changes in the rural industrial structure. Rural electrification construction has provided a reliable foundation for eliminating poverty and bringing prosperity and an economic takeoff in rural areas.

B. The Structure of Rural Labor Power Has Changed

The availability of small-scale hydropower in mountainous areas has promoted the development of mechanization. Electricity is now used for milling rice, grinding flour, threshing, pulverizing feed, and other uses. This saves labor power and provides the conditions for commodity production and a shift from a simple agricultural economy to a diversified economy of agriculture, forestry, animal husbandry, sideline production, fishery, industry, commerce, construction, transport, and services, and has promoted the shift of labor power toward secondary and tertiary industries. Preliminary statistics show that 92.75 percent of the villages in the 100 counties had electricity and 97.5 percent of peasant households no longer used manual labor for milling rice and grinding flour. With the additional development of township and village enterprises, 3.02 million agricultural laborers were shifted over 5 years to become new type peasants who left the soil without leaving their villages. These people work, create value, and consume locally, which benefits social stability and reduces pressures on cities. Rural electrification has created the conditions for local employment of surplus labor power.

C. Farmland Drought Resistance and Drainage Capabilities Have Improved

Before liberation, China experienced frequent destruction by flooding and droughts. While building water conservancy and small-scale hydropower, we also used comprehensive planning and control to implement multi-goal development, which has effectively increased farmland drought resistance and drainage capabilities. Guangdong Province's Enping County used comprehensive control and development of the Jing Jiang basin to develop 36 MW of small-scale hydropower and water diversion and water lifting to irrigate 280,000 mu of farmland along both banks. They eliminated the threat of flooding and waterlogging on 120,000 mu of farmland. Guangxi Province's Guangfeng County has built 18 MW of small-scale hydropower. The county now has 214 electrically powered water lifting pumps which have enabled irrigation of several "fields dependent on the skies." They have expanded the effective irrigation area to 250,000 mu.

D. Benefits for Restoring and Protecting the Ecological Equilibrium

Most of China's rural villages have an energy resource shortage, and there is roughly a one-third shortage of civilian fuels. The peasants cut trees, pull up grass, and burn straw and dung to cook food. The result is ecological damage and soil erosion, and the soil is becoming increasingly unproductive. In regions where small-scale hydropower has developed to a greater extent, some peasants are using surplus electric power and abundant hydropower for cooking and boiling water, which helps to protect forests and vegetation. About 1.1 million peasant households in about one-fourth of China's mountainous counties are now using seasonal electric power for cooking. Xinchang County in Zhejiang Province uses small-scale hydropower to process tea, which can save about 6,000 cubic meters of timber and 2,800 tons of raw coal each year, and it has improved the quality of the tea. Integration of small-scale hydropower construction with control of medium-sized and small river basins has brought enormous improvements to agricultural production conditions and promoted ecological equilibrium.

E. Construction of Material and Spiritual Civilization Has Been Promoted in Rural Areas

The widespread availability of electric power is a starting point for achieving rural modernization. There must be electricity if we are to invigorate the rural economy and improve the quality of rural culture. The universal availability of electric power has played an enormous role in promoting construction of material and spiritual

civilization in rural areas. There are 6.78 million households in the 100 trial rural electrification counties which have electricity, equal to 90.85 percent of the total number of households. In the past 5 years, 10.08 million peasants in remote areas have stopped using pine branches for illumination and manual labor to grind flour and mill rice. Televisions, radios and cassette recorders, electric refrigerators, and washing machines have begun to enter peasant homes. Preliminary statistics indicate that the net per capita income in the 100 trial rural electrification counties increased from 198 yuan to 500.98 yuan over the 5-year period.

F. Accumulating Capital for Local and Collective Expanded Reproduction

Statistical data from a survey in Sichuan Province show that the province has 403 state-run small-scale hydropower stations with a capacity of 736.4 MW. They earned 122 million yuan in profits in 1988 and paid 29 million yuan in taxes. Their average profits and taxes were 205 per kW. Longfeng and Xiaobaita Hydropower Stations in Sichuan Province produced 142 million kWh of power in 1988 and earned 4.51 million yuan in profits. They paid 500,000 yuan in taxes and earned an average of 222 yuan in profits and taxes and set aside 274.1 yuan for accumulation per kW. Guangdong allocates 20 million yuan each year from small-scale hydropower profits to develop small-scale hydropower by "using power to develop power." Xiaoyuan Village in Baizhang Township, Minqing County, Fujian Province built a 55 kW small-scale hydropower station which earned over 20,000 yuan in income each year. This income was used to build rural bridges and to expand a 125 kW small-scale hydropower station.

III. Some Experiences

A. Attention From the Leadership and Support by the Masses Are the Motive Forces in Developing Small-Scale Hydropower

Developing small-scale hydropower to achieve rural electrification is of concern to millions of families and all industries. It is not enough to have an active hydropower department. Attention from the leadership and support by all industries and the masses are also required. The concern of basic level leaders in counties and townships is especially important. Enormous enthusiasm can be motivated only if they understand that developing small-scale hydropower and building rural electrification are related to invigoration of an entire county's economy and the key to eliminating poverty and prosperity. Sichuan Province's Shizhu County is a poor mountainous county. Leading elements in the county have consistently understood that the power shortage has become the key factor which restricts development of the entire county's economy. They decided in 1987 that besides education and agriculture, all industries in the county should cease capital construction and concentrate all their capital on building small-scale hydropower. They mobilized the masses to make investments and provide labor, and built eight power stations and expanded five power stations in 1 year. They doubled the installed generating capacity within the county's small-scale hydropower grid, doubled its output during the dry season, and doubled the amount of 35 kV lines. The next year, there was a 56 percent increase in the county's gross value of industrial output, which promoted economic development in the county as a whole. Construction in all of China's 100 trial rural electrification counties has involved leaders in all counties organizing leadership groups with participation by leaders from all county industries for joint planning and joint implementation. County leaders are responsible for on-site direction of all key projects. All provinces (autonomous regions) of south China have held several meetings in the provincial governor's offices to study problems in implementing the trial counties program.

B. Adhering to the Idea of Many Levels Developing Power and the Masses Developing Power, and Implementing the Principle of "Self-Construction, Self-Management, Self-Utilization" Are the Keys to Guaranteeing Stable Development of Small-Scale Hydropower

The main reason for small-scale hydropower's ability to develop so quickly since the nation was founded is that there was sufficient reliance on local areas, mobilization of the masses, advocacy of multilayer and multichannel power development by provinces, prefectures, counties, townships, and villages, and implementation of the policy of "those who build being the owners, the managers, and the recipients of benefits" which protected the interests of those who develop power. On the basis of summarizing experiences in developing small-scale hydropower, Premier Li Peng formulated the "three selves" principle in 1983 calling for "self-construction, self-management, and self-utilization." This epitomized the preferential policies of central authorities toward local development of small-scale hydropower and assured the direction of policies and services. It crystallizes experiences in developing small-scale hydropower since the nation was founded.

C. Implementing a Management System for Unified Construction and Management and for Unified Power Generation, Supply, and Use Is an Important Measure for Motivating Local Initiative To Develop Power

Practice in the 100 trial rural electrification counties has proven that establishing a management system which unifies construction and management and unifies power generation, supply, and use within a single county and which makes counties the concrete body for unified planning with dispatching and management by levels can help eliminate the contradiction between construction and management and the generation, supply, and use of power. It also is extremely helpful in protecting initiative to develop power, perfecting management, implementing "using power to develop power," capital accumulation, and so on.

D. Implementing Policies for "Using Power To Develop Power," Raising Capital From Many Areas, and Appropriate Support From the State Are an Important Way To Provide Capital for Developing Power

"Using power to develop power" is an important policy for developing small-scale hydropower. The 100 trial rural electrification counties input a total of 2.822 billion yuan in construction capital over 5 years. In 1985, the state began providing 100 million yuan in subsidies as "revised allocation credit" capital, for a total of 400 million yuan, equal to 14.17 percent. All of the remainder was raised from several sources. There was a total of 610 million yuan in "using power to develop power" capital over 5 years, equal to 21.62 percent of the total investment. Practice shows that by providing appropriate capital support for small-scale hydropower, the state can mobilize large amounts of local capital. Sichuan Province's Hongya County, for example, invested a total of 50.42 million yuan in rural electrification construction over 5 years. This included 3.2 million yuan in revised allocation credit from the state, equal to 6.3 percent. Bank loans and electric power bonds provided 21.55 million yuan, equal to 42.8 percent. Capital raised by the local area itself (including that from using power to develop power) came to 25.67 million yuan, equal to 50.9 percent.

E. Do Good Planning and Implement Synchronous Development of Power Sources, Power Grids, and Power Use Loads

Counties have lacked comprehensive plans for small-scale hydropower construction for many years. In the area of power sources, there are many runoff power stations, poor regulation capabilities, and low guaranteed output. In the area of grids, they have been gradually expanded by taking one step and then looking ahead one step as power sources are built and loads develop. The result is irrational deployment and problems in fostering benefits. There is no matchup between power use loads and power sources, resulting in much blind action. Plans for the 100 trial counties met this problem head-on and used a balance between power output and amount of water for electric power along with economic accounting to readjust the structure of power sources and grids. This gave the overall plans a reliable foundation allowed synchronous development of power generation, supply, and use, and achieved rapid paces and good benefits. This provides important experience for future small-scale hydropower development and achieving rural electrification.

F. Reinforcing Management and Invigorating Enterprises Are the Keys To Solidifying Achievements and Forming Self-Transformation and Self-Development Capabilities

Managing power stations and grids well is an important link in solidifying small-scale hydropower development achievements and fostering the benefits of small-scale hydropower. Practice has proven that the quality of management work concerns "using power to develop power" for small-scale hydropower, the capacity for loan repayment, employee welfare, equipment renewal, and many other important issues, and it concerns the existence and development of small-scale hydropower. For the past 10 years, reinforced management and stronger coordination of power sources with water sources have strengthened regulation capabilities. They have perfected grid structures and expanded grid integration. In power use, there has been concern for readjusting load structures and utilizing seasonal power to raise scientific dispatching levels. These things have increased the yearly utilization time for China's small-scale hydropower equipment from 1,894 hours in 1978 to 2,820 hours in 1988, which is equivalent to placing several 100 MW in installed generating capacity into operation each year, so the benefits are obvious. The recent National Rural Hydropower Work Conference stressed continued reinforcement of management and called on all medium and small-scale hydropower enterprises to implement comprehensive contractual responsibility management systems, gradually undertake work to raise enterprise grades, intensify reforms, invigorate enterprises, and focus on safe production, be concerned with coordinating technical innovation and exploiting potential in small-scale hydropower to improve the quality of power supplies, focus on comprehensive administration and horizontal integration in electric power enterprises, and gradually form small-scale hydropower enterprise groups to strengthen the capacity for self-transformation and self-development.

G. Fully Utilizing Seasonal Power Is an Important Way To Improve the Economic Benefits of Small-Scale Hydropower

Like large grids, small-scale hydropower grids in regions of China with abundant small-scale hydropower resources also had to discard water during the rainy season and restrict power during the dry season. This is particularly true in the provinces (autonomous regions) of south China where the small-scale hydropower installed generating capacity is nearly 30 to 40 percent of the installed generating capacity in large grids. In a situation of similar grid structures, large grids are unable to deal with the problems of a loss of equilibrium from an irrational structure power source structure in small grids. They often refuse to accept power output from small-scale hydropower during peak water amounts and low valleys. The additional factor of a low rural load rate intensifies the problem of discarding water for small-scale hydropower. For this reason, besides increasing the regulation and storage capabilities of small-scale hydropower grids and improving the power source structure, full utilization of seasonal power is an important measure for improving economic results. Over the past few years, many small-scale hydropower grids have developed some industrial loads to carry the power (calcium carbide, iron alloys, carborundum, yellow phosphorous, etc.). They absorb seasonal power and reduce the contradiction between large and small grids, utilize the regulatable characteristics of this type of load to raise

the load rate within the grids, and play a definite role in filling valleys at night, with benefits that are quite apparent.

Accelera: ng development of medium and small-scale hydropower and pushing the pace of small-scale hydropower are related to the two strategic focuses of agriculture and energy resources. They concern increased reserve strengths for agricultural development, full invigoration of the rural economy, and construction of spiritual civilization for 800 million peasants. For this reason, active development of medium and small-scale hydropower and construction of small-scale hydropower with Chinese characteristics has special strategic significance. Recently, the Ministry of Water Resources Rural Hydropower Department compiled a national program outline for local medium and small-scale hydropower development based on medium and small-scale hydropower plans reported by all areas. The plan proposes developing 14,580 MW in local medium and small-scale hydropower installed generating capacity between 1989 and 2000, including 10,580 MW in small-scale hydropower, building 400,000 kilometers of high voltage lines and 46.40 million kVA of power transformation equipment in conjunction with local grids, and establishing 500 counties on the basis of the 100 preliminary rural electrification counties.

In the 40 years since the nation was founded, China's hundreds of millions of peasants have built many hydropower stations in sequence like a chain of pearls inlaid on the motherland's beautiful territory. They have brought life and prosperity to our vast rural areas. The masses now acknowledge the advantages of building small-scale hydropower, and the ability of small-scale hydropower to promote rural electrification has been confirmed by the facts. After a long period of struggle we have laid a substantial material and technical foundation. If we conscientiously adhere to the principles and policies of central authorities, rely on our own efforts, adapt to local conditions, are bold in opening up and in practice, continue to display the excellent tradition of hard work, and closely rely on local areas and rely on peasants who are becoming prosperous, China's small-scale hydropower will certainly move solidly and stably forward in achieving the magnificent cause of rural electrification.

Footnotes

1. This does not include 276.3 MW at 23 hydropower stations smaller than 25 MW directly managed by the electric power system which produced 811 million kWh of power in 1988.

Status of Nation's 12 Major Hydroelectric Bases

906B0015H Beijing SHUILI FADIAN [WATER POWER] in Chinese No 10, 12 Oct 89 p 00

[Table: "Scale and Development Situation for China's 12 Large Hydropower Base Areas" and map: "China's 12 Large Hydropower Base Areas and Locations of Power Stations Larger Than 1,000 MW"]

[Text]

Scale and Development Situation for China's 12 Large Hydropower Base Areas

Name of base area/ Item	Total scale		Names of power stations already completed at end of 1988 and installed generating capacity in MW [converted from 10,000 kW]	Names of power stations under construction in 1989 and installed generating capacity in MW [converted from 10,000 kW]	Main power stations awaiting development and installed generating capacity in MW [converted from 10,000 kW]
	Installed generating capacity in MW [converted from 10,000 kW]	Yearly power output in billion kWh [converted from 100 million kWh]			
1. Jinsha Jiang from Shuigu to Yibin	46,230 MW	261.08 billion kWh			Hutiao Gorge (6,000 MW), Hongmenkou (3,750 MW), Zili (2,080 MW), Pichang (2,700 MW), Guanyinyan (2,800 MW), Wudongde (5,600 MW), Baihetan (8,300 MW), Xiluodu (10,000 MW), Xiangjiaba (5,000 MW)

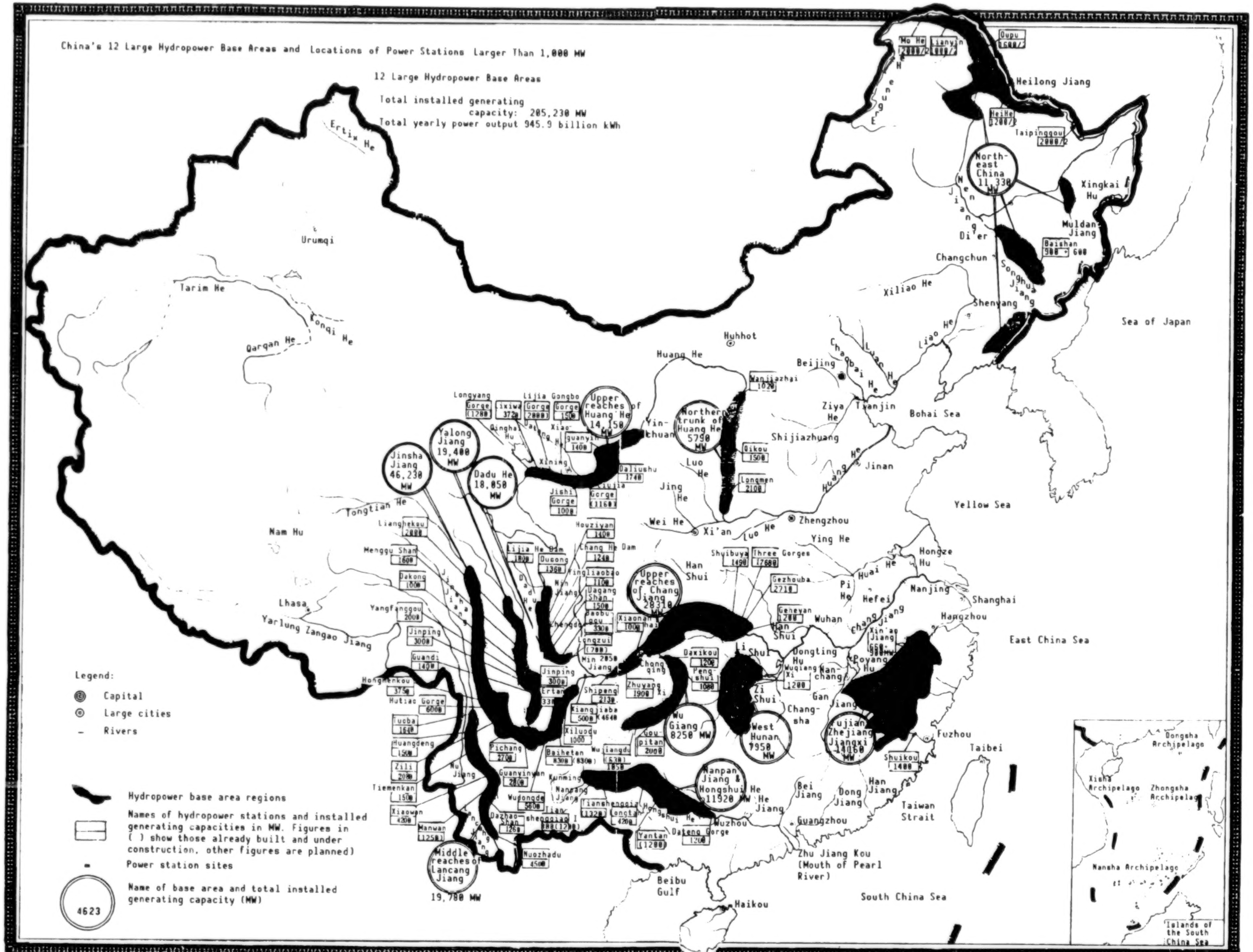
Scale and Development Situation for China's 12 Large Hydropower Base Areas (Continued)

Name of base area/ Item	Total scale		Names of power stations already completed at end of 1988 and installed generating capacity in MW [converted from 10,000 kW]	Names of power stations under construction in 1989 and installed generating capacity in MW [converted from 10,000 kW]	Main power stations awaiting development and installed generating capacity in MW [converted from 10,000 kW]
2. Yalong Jiang from Lianghekou to Hekou	19,400 MW	104.87 billion kWh		Ertan (3,300 MW)	Lianghekou (2,000 MW), Yagen (900 MW), Menggu Shan (1,600 MW), Dakong (1,000 MW), Yangfanggou (2,000 MW), Kalaxiang (800 MW), Jinping first cascade (3,000 MW), Jinping second cascade (3,000 MW), Guandi (1,400 MW), Tongzilin (400 MW)
3. Dadu He from Shuangjiangkou to Tongjiezi	18,055 MW	92.47 billion kWh	Longzui (700 MW), ultimate scale after increasing height 2,055 MW	Tongjiezi (600 MW)	Dusong (1,360 MW), Manai (300 MW), Lijia He Dam (1,800 MW), Houziyan (1,400 MW), Chang He Dam (1,240 MW), Lengzhuguan (900 MW), Luding (600 MW), Yingliaobao (1,100 MW), Dagang Shan (1,500 MW), Longtoushi (500 MW), Laoyingyan (600 MW), Baobugou (3,300 MW), Shenxigou (360 MW), Zhentou Dam (440 MW)
4. Trunk of Wu Jiang	8,255 MW	40.451 billion kWh	Wujiangdu (630 MW)	Puding (75 MW), Dongfeng (510 MW)	Yinzidu (160 MW), Hongjiadu (540 MW), Sufengying (420 MW), Goupitan (2,000 MW), Silin (840 MW), Shatuo (800 MW), Pengshui (1,080 MW), Daxikou (1,200 MW)
5. Upper reaches of Chang Jiang from Yibin to Yichang, including Qing Jiang	28,316 MW	121.99 billion kWh	Gezhouba (2,715 MW)	Geheyan (1,200 MW)	Shipeng (2,130 MW), Zhuyang Xi (1,900 MW), Xiaonanhai (1,000 MW), Three Gorges (17,680 MW), Shuibuya (1,491 MW), Gaobazhou (200 MW)
6. Nanpan Jiang and Hongshui He (data for Beipan Jiang still not available)	11,920 MW	50.25 billion kWh	Etan (60 MW), Dahua (400 MW)	Tianshengqiao second cascade (1,320 MW), Yantan (1,200 MW)	Tianshengqiao first cascade (1,200 MW), Pingban (360 MW), Longtan (4,200 MW), Bailongtan (180 MW), Etan (500 MW), Qiaogong (500 MW), Dateng Gorge (1,200 MW), Lubuge (600 MW), Dahua (200 MW)

Scale and Development Situation for China's 12 Large Hydropower Base Areas (Continued)

Name of base area/ Item	Total scale		Names of power stations already completed at end of 1988 and installed generating capacity in MW [converted from 10,000 kW]	Names of power stations under construction in 1989 and installed generating capacity in MW [converted from 10,000 kW]	Main power stations awaiting development and installed generating capacity in MW [converted from 10,000 kW]
7. Trunk of Lancang Jiang within boundaries of Yunnan Province	19,780 MW	101.03 billion kWh		Manwan (1,250 MW)	Liujian Jiang (550 MW), Jiabi (430 MW), Wulonglong (800 MW), Tuoba (1,640 MW), Huangdeng (1,500 MW), Tiemenkan (1,500 MW), Gongguoqiao (750 MW), Xiaowan (4,200 MW), Dazhao Shan (1,260 MW), Nuozhadu (4,500 MW), Jinghong (900 MW), Ganlan Dam (100 MW), Nan'-ahekou (400 MW)
8. Upper reaches of Huang He from Longyang Gorge to Qingtong Gorge	14,154.8 or 14,254.8 MW	50.793 or 50.916 billion kWh	Liujia Gorge (1,160 MW), Yanwo Gorge (396 MW), Bapan Gorge (180 MW), Qingtong Gorge (272 MW)	Longyang Gorge (1,280 MW), Lijia Gorge (2,000 MW)	Laxiwa (3,720 MW), Gongbo Gorge (1,500 MW), Jishi Gorge (800-1,000 MW), Sigou Gorge (250 MW), Xiaoxia (200 MW), Daxia (300 MW), Wujin Gorge (132 MW), Xiaoguanyin (1,400 MW), Daliushu (440 MW) (1,740 MW)
9. Northern trunk of the middle and upper reaches of Huang He from Hezkou Town to Yumenkou	5,792 MW	19.69 billion kWh	Tianqiao (128 MW)		Wanjiazhai (1,020 MW), Longkou (400 MW), Qikou (1,500 MW), Jundu (300 MW), Sanjiao (200 MW), Longmen (2,100 MW), Yumenkou (144 MW)
10. West Hunan, including the Zi Shui, Yuan Shui, and Li Shui, with Qingshui Jiang added	7,951 MW	31.823 billion kWh	Fengtan (700 MW), Zhexi (447.5 MW), Majitang (55 MW), Sanjiangkou (62.5 MW)	Wuqiang Xi (1,200 MW)	Yuan Shui (1,535.3 MW), Zi Shui (576 MW), Li Shui (2,036.7 MW), Qingshui Jiang (1,338 MW)
11. Fujian-Zhejiang-Jiangxi, including all rivers in Fujian, Zhejiang, and Jiangxi	14,168.2 MW	41.171 billion kWh	Fujian (589 MW), Zhejiang (1,484.7 MW), Jiangxi (312.7 MW)	Fujian (1,766 MW), Zhejiang (108 MW), Jiangxi (500 MW)	Fujian (3,800.4 MW), Zhejiang (2,717.2 MW), Jiangxi (2,890.2 MW)
12. Northeast China, includes Heilong Jiang, Mudan Jiang, Second channel Songhua Jiang, Yalu Jiang, Hun Jiang, and Nen Jiang	11,335.5 MW	30.936 billion kWh	3,739.5 MW		Plans call for a total of 33 power stations of all types with an installed generating capacity of 7,569 MW
Total	205,232 or 205,132 MW	945.88 or 945.93 billion kWh	14,231.9 MW	16,309 MW	174,691 to 174,891 MW or 174,591 to 174,791 MW

(Note: Data on hydropower base areas in this special issue of SHUILI FADIAN provided by Zhou Lijuan [0719 7787 1227] in the Water Resources and Hydropower Planning and Design Academy)


China's 12 Large Hydropower Base Areas and Locations of Power Stations Larger Than 1,000 MW
12 Large Hydropower Base Areas
Total installed generating capacity: 205,230 MW
Total yearly power output 945.9 billion kWh
Legend:
Capital
Large cities
Rivers
Hydropower base area regions
Names of hydropower stations and installed generating capacities in MW. Figures in ( ) show those already built and under construction, other figures are planned)
Power station sites
Name of base area and total installed generating capacity (MW)
4623
Jinsha Jiang 46,230 MW
Yalong Jiang 19,400 MW
Dadu He 18,050 MW
Upper reaches of Huang He 14,150 MW
Northern trunk of Huang He 5790 MW
Upper reaches of Chang Jiang 28310 MW
Wu Jiang 8250 MW
West Hunan 7950 MW
Fujian Zhejiang Jiangxi 14060 MW
Nanpan Jiang & Hongshui He 11920 MW
Middle reaches of Lancang Jiang 19,700 MW
North-east China 11,330 MW
Heilong Jiang
Xingkai Hu
Mudan Jiang
Changchun
Shenyang
Songhua Jiang
Xiliao He
Liao He
Sea of Japan
Hohhot
Beijing
Tianjin
Bohai Sea
Shijiazhuang
Jinan
Yellow Sea
Zhengzhou
Xi'an
Wei He
Huang He
Han Shui
Wuhan
Nanjing
Shanghai
Hangzhou
East China Sea
Changsha
Fuzhou
Taibei
Taiwan Strait
Guangzhou
Zhu Jiang Kou (Mouth of Pearl River)
South China Sea
Beibu Gulf
Haikou
Urumqi
Tarim He
Lhasa
Yarlung Zangbo Jiang
Tongtian He
Nam Hu
Three Gorges
Gezhouba 2715
Longyang Gorge (1280)
Lijia Gorge 2000
Longmen 2100
Wanjiazhai 1020
Baishan 900 + 600
Shuikou 1400
Dongsha Archipelago
Xisha Archipelago
Zhongsha Archipelago
Nansha Archipelago
Islands of the South China Sea

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